

**STUDIES ON ENERGETICS OF WHEAT CROP
PRODUCTION IN TARAI REGION OF
UTTARAKHAND**

Thesis

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By

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Pantnagar
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CERTIFICATE

This is to certify that the thesis entitled “**STUDIES ON ENERGETICS OF WHEAT CROP PRODUCTION IN TARAI REGION OF UTTARAKHAND**” submitted in partial fulfillment of the requirements for the degree of **MASTER OF TECHNOLOGY IN AGRICULTURAL ENGINEERING** with major in **Farm Machinery and Power Engineering**, of the College of Post-Graduate Studies, G.B. Pant University of Agriculture & Technology, Pantnagar, is a record of bona-fide research carried out by **Mr. Rajat Kumar Sharma, Id. No.48164**, under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation and source of literature have been duly acknowledged.

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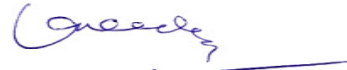
We, the undersigned, members of the Advisory Committee of **Mr. Rajat Kumar Sharma, Id. No.48164**, a candidate for the degree of **MASTER OF TECHNOLOGY IN AGRICULTURAL ENGINEERING** with major in **FARM MACHINERY AND POWER ENGINEERING**, agree that the thesis entitled **“STUDIES ON ENERGETICS OF WHEAT CROP PRODUCTION IN TARAI REGION OF UTTARAKHAND”** may be submitted in partial fulfillment of the requirements for the degree.



(T. K. Bhattacharya)
Chairman
Advisory Committee



(Jayant Singh)
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(Lokesh Varshney)
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LIST OF ABBREVIATION

η	:	Conveyance efficiency
$^{\circ}\text{C}$:	Degree Celsius
μ	:	Mean of the Data Set
A_i	:	Input Factors
CFMTTI	:	Central Farm Machinery Training and Testing Institute
C_i	:	Energy Coefficient for Input Factor
D	:	Diameter of Disc
<i>et al.</i>	:	and others
FAO	:	Food and Agricultural Organization of United Nation
Fig.	:	Figure
FYM	:	Field Yard Manure
h	:	Hour
ha	:	Hectare
HSD	:	High Speed Diesel
IS	:	Indian Standard
Kg	:	Kilogram
Km	:	Kilometer
KVK	:	Krishi Vigyan Kendra
kW	:	Kilo Watt
kWh	:	Kilo Watt Hour
L	:	Litre
LA	:	Sum of Work Done by Draft Animal
LCF	:	Load Coefficient Factor
LH	:	Sum of Work Done by Human

LM	:	Sum of Work Done by Machine
ME	:	Machine Energy
MI	:	Mechanization Index
MJ	:	Mega Joule
ml	:	Mililitre
MMT	:	Million Metric Tonne
No.	:	Number
No. of WD	:	Number of Available Working Days
No. of WH	:	Number of Working Hours Per Day
No.of IR	:	Number of Implement Required
PTO	:	Power Take Off
Q	:	Discharge of Irrigation Pump
RHP	:	Rated Horse Power
S	:	Spacing between the discs
SD	:	Standard Deviation
SFC	:	Specific Fuel Consumption
T	:	Time of Operation
TFC	:	Theoretical Field Capacity
UCA	:	Uncovered Cultivated Area
W	:	Width of Cut



Introduction



INTRODUCTION

Agriculture is a production-oriented sector, requires energy as an important input for crop production. Global food security demands an increase in agriculture production as total cultivable land is decreasing and the population of the world is increasing day by day. In general, various alternatives for increasing agricultural production can be characterized in the form of additional land use, increase yield per unit area and increased cropping intensity. As it is not possible to increase cultivable land for agriculture production, the substantial change in the production may be increased by increasing the use of energy resources.

Agricultural economic development is highly correlated with the amount of energy used. Energy is the key input of crop production. Crop yield is affected by the use of energy sources and their magnitude like human power, machines, irrigation, fertilizers, pesticides, diesel etc. Energy is one of the important elements in modern agriculture as it heavily depends on fossil and other energy resources. Energy consumption in agriculture has been increasing in response to the limited supply of arable land, increasing population, technological changes, and a desire for higher standards of living (**Kizilaslan, 2009**). Some studies show that there is a positive relationship between energy usage and productivity. The need to increase food production has resulted in the increased consumption of energy and natural resources because farmers have little knowledge of incentives to use more energy efficient methods (**Esengun et al., 2007**).

The increased use of inputs such as fertilizer, irrigation water, diesel, plant protection chemicals, electricity etc. demands more energy in the form of human, animal and machinery. The commercial energy used in agriculture increased nearly six fold with the growth rate of 11.8% between 1980-81 to 2000, but the share of agriculture in total energy consumption in the country increased from 2.3 to 5.2% during the same period (**Singh, 2002**).

Agriculture is both a producer and consumer of energy. It uses large quantities of locally available non-commercial energy, such as seed, manure and animate energy, as well as commercial energy sources, directly and indirectly, in the form of diesel, electricity, fertilizer, plant protection, chemical, irrigation water, machinery

etc. Efficient use of these energy sources helps to achieve increased production and productivity and contributes to the profitability and competitiveness of agriculture sustainability in rural living (**Singh *et al.*, 2002**).

Energy productivity is an important indicator for more efficient use of energy although higher energy productivity does not mean in general, more economic feasibility. The energy input-output analysis is usually made to measure the energy efficiency and environmental aspects. This analysis will determine how efficient the energy is used (**Mohammadi *et al.*, 2010**).

The forgoing discussion suggests that the increased production requires development and efficient application of energy resources. The efficient use of energy resources depends on the status of agricultural mechanization of the farmer and sources of farm power. Agricultural mechanization and availability of machinery help to perform the agricultural operations timely which increase crop yield as well as cropping intensity. The level of farm power use differs markedly on different categories of farmers depending upon the adoption of modern technology and acquisition of other capital resources. This difference of resources also changes the energy use pattern and efficiency of crop production.

Wheat (*Triticum* spp.) is the most important cereal crop in India. As per FAO statistics, the average annual production of wheat in India comes to about 94.88 MMT, over a period 6 years (2007–2012), against world's average of 595.7 MMT over the same period. Thus, India contributes about 12% to the world wheat production. Further, according to the FAO data (2005), India is the second largest producer of wheat (95 MMT) next only to China (121 MMT) followed by USA (62 MMT), France (40.30 MMT) and Canada (27.20 MMT). India covers the largest area under wheat cultivation (26.5 million ha), which is about 12.2% of the World's wheat area (217 million ha).

In Uttarakhand, wheat is an important crop of rice-wheat crop rotation. Wheat is cultivated on 0.35 million ha area which is 38.10% of the total cultivable area (0.91 million ha) of Uttarakhand. The average yield of the wheat crop in Uttarakhand is 2.46 t/ha. The overall wheat production in Uttarakhand is 0.84 MMT (**Statistical Diary of Uttarakhand, 2015**).

The agriculture in Tarai region of Uttarakhand is much more advanced as compared to hill region of the state. The introduction of green revolution resulted in

steady growth in food grain production in the region, but through a high energy intensive agriculture. The average yield of wheat crop in Udham Singh Nagar district is 3.8 t/ha. (**KVK, Udham Singh Nagar**)

Observing the above facts, it is therefore imperative that steps are taken to assess the energy requirements, energy balance, energy productivity, effect of farm mechanization status on energy consumption pattern and identify the energy efficient systems for varying energy use of growing major crops in the region.

In view of the preceding discussion, the present study was undertaken to analyse the energy consumption pattern of selected unit operations in wheat crop production in Tarai region of Uttarakhand with following major objectives

1. To study the farm power availability and farm mechanization index in cultivation of wheat crop in Tarai region of Uttarakhand.
2. To estimate the consumption of direct and indirect energy in wheat crop production system in Tarai region of Uttarakhand and forecasting of the future demand of energy.



*Review
of
Literature*



REVIEW OF LITERATURE

The energy consumption in production agriculture in raising a particular crop varies because of agro-climatic location, crop production and management practices, farm power availability, mechanization status, use of direct and indirect energy in different forms and other agricultural inputs. Tarai region of Uttarakhand and adjoining area of Uttar Pradesh are highly mechanized and productive. Wheat, rice and sugarcane are the major crops of the region. The yield of crops in this region is comparable to the other productive areas of India. A brief review of the literature on the farm power availability in India and Tarai region of Uttarakhand, farm mechanization status in India and in the region, energetics of wheat crop production in India as well as the different energy saving equipment in the wheat production system is presented in this chapter.

2.1 Farm Power Availability

2.1.1 Farm power availability in India

Rehman (1995) reviewed the status of mechanization in eleven Asian countries and reported that the use of agricultural machinery was increasing in all the countries including India since early 1970. In context to India, it was reported that four-wheel tractors in India increased at a rate of 19% during 1971-80 and 10% during 1981-90. Power tillers increased at a rate of 19% during 1981-90. The average yearly percentage increase in other agricultural machinery in India was presented as shown in Table 2.1

Table 2.1 Average Yearly Percentage Increase in Use of Agricultural Machinery in India

Name of Machine	Percentage Increase	
	1971-80	1981-90
Four Wheel Tractors	19	10
Power Tillers	11	17
Power Tillers	15	17
Sprayers	9	36
Reapers/Harvesters	30	26
Shellers/Threshers	14	23

Srivastav (2002) reported the farm power status in India. The farm power availability was 1.35 kW/ha in the year 2001. For the same period, it was 3.5 kW/ha in the state of Punjab. The total population of tractors and power tiller was 27, 59,936 and 93,884 units respectively. The density of tractor was 12.18/1000ha. It was also been reported that productivity of food grains was linearly proportional to farm power availability. The year wise population of tractors and power tillers in India as reported is shown in Table 2.2.

Table 2.2 Year Wise Population of Tractors and Power Tillers in India

Year	Tractor	Power Tiller
1947	4500	-
1951	8500	-
1961	39000	2
1971	176000	13008
1981	594000	15406
1991	1304000	34614
2000	2759936	93884

De et al. (2006) studied the farm power use pattern in Indian farms. Results indicated that Indian farms had farm power availability of 0.295 kW/ha only in 1971 and was mainly dominated by animal power (45.3%). The farm power availability in the year 2005 was 1.5 kW/ha. This increase in farm power availability was mainly due to the introduction of tractors whose contribution increased by 7.5% in 1971 to 42% in 2001. The study also indicated that in India tractor density varies from 0.9 to 71.4 tractors/1000ha amongst the different states. The highest tractor density was in Punjab (71.4 tractors/1000ha) followed by Haryana (60.1 tractors/1000ha) and Uttar Pradesh (28 tractors/1000ha) while Orissa and West Bengal had low tractor density of 1.3 and 1.5 tractors/1000ha respectively.

Singh and Mani (2009) studied the trends in agricultural mechanization in India and reported that there was a large spatial variation in tractor density both interstate and intrastate. The highest concentration of tractors was in northern India.

The average size of tractors in India was 35 hp. This average size was slowly increasing and is expected to increase to 45 hp by the year 2020. The total number of power tillers in India was estimated to be around 152000. The total estimated population of electric motors and diesel engine was reported as 10 million and 7.5 million respectively.

Mandal and Maity (2013) studied the trends of Indian tractor industries between the period 1997-2001. The study reported that Indian tractor market is traditionally medium horsepower market (31-40 hp) accounting 45% of total tractor industry. A farmer choice of the tractor is typically a trade-off between the utility of tractor and its price. Study also indicated the year wise present share of different horsepower tractors of their total sales and is shown in Table 2.3.

Table 2.3 Total Share of Sales of Different Tractors

hp Range	Percent Share			
	1997-98	1998-99	1999-00	2000-01
≤25	7	7	6	4
25-30	12	15	20	20
31-35	51	51	46	45
36-40	9	8	9	10
41-45	5	4	7	8
≥45	15	15	12	14

Singh et al. (2014) conducted studies on the status of farm power availability in India. It was reported that farm power availability in India had reached from 0.30 kW/ha to 2.02 kW/ha in the period between 1960-61 to 2013-14. The share of animal power reduced from 92.3% to 11.8% during this period. Mechanization of crop cultivation also showed the upward trend during this period as the farm power availability increased. The study also reported that farm power input has to be increased further to meet higher food demand.

Mehta et al. (2014) studied trends of agricultural mechanization in India. The study shows that farm power availability in India was 1.698 kW/ha in 2011-12 and

1.841 kW/ha in 2012-13. The share of mechanical power sources was 90% of total farm power availability though the overall mechanization level in India was only 40-45%. The percent share of agricultural workers and draught animal power sources in total power decreased from 15.4% to 5.0% and 45.4% to 5.1% respectively in the period 1970 to 2013. The combined share of agricultural workers and draught animals in total farm power availability in India reduced from 60.8% in 1971-72 to 10.1% during 2012-13. The share of tractors and electric motors in farm power availability was increased from 6.8 % to 45.8% and 14% to 26.8% in the same period. The year wise farm power availability in India as reported is presented in Table 2.4.

Table 2.4 Power Availability on Indian Farms

Year	Power Availability (kW/ha)	Net Area Per Tractor (ha/tractor)
1975-76	0.36	487
1985-86	0.58	174
1995-96	0.92	84
2005-06	1.50	47
2010-11	1.68	31
2012-13	1.84	30

Singh (2015) reported the status of farm power in India. Human power availability for agriculture increased from 0.043 kW/ha 0.96 kW/ha between the period 1960-61 to 2013-14 but the share of agriculture workers in total farm availability was reduced from 14.7% to 4.66% in the same period. Draught animal power availability in India reduced from 0.229 kW/ha to 0.14 kW/ha between 1960-61 to 2013-14. The share of draught animal power reduced from 78% to 7% in the same period. Farm power availability from tractors consequently increased from 0.007 kW/ha to 0.218 kW/ha in the period between 1960 to 1990 at an annual growth rate of 12.14 % and 0.47 to 0.97 kW/ha in the period between 2000 to 2013 at an annual growth rate of 9.80%. Farm power availability from diesel engines increased from 0.009 kW/ha in 1960 to 0.335 kW/ha in 2013-14. The farm power availability from electric motors increased exponentially from 0.005 kW/ha to 0.445 kW/ha. Total

farm power availability increased from 0.32 kW/ha to 2.02 kW/ha in the period between 1960-61 to 2013 -14.

2.1.2 Farm power availability in Tarai region of Uttarakhand

Srivastava and Tyagi (1993) studied the available gross power in Naul and Jaipur Bhisha villages of Tarai region of Uttarakhand. It was reported that average gross power per hectare in Naul village was 1.63 kW/ha whereas it was 1.1 kW/ha in village Jaipur Bhisha. The ratio of human power to draught animal power was 6.7 and 10.4 for Naul village and Jaipur Bhisha village respectively. The numbers of tractor drawn implements were higher in Jaipur Bhisha as compared to Naul village.

Singh *et al.* (1997) studied the mechanization level status of Tarai and Western regions of Uttar Pradesh (now in Uttarakhand) and found that average farm power availability in Tarai region was 2.47 kW/ha. Farm power availability for marginal, small, medium and large farmers was 0.16, 0.07, 5.78 and 2.9 kW/ha respectively. The study also reported that power availability for different categories was sufficient up to the desired level of cropping intensity (135%).

2.2 Farm Mechanization Status in India

Rahman (1995) reviewed the mechanization status in Indian farms and ten other Asian countries and emphasized the need to manufacture simple, reliable and inexpensive machines, which can perform the intended function efficiently. The estimated annual demands of agricultural machinery such as tractors, power tillers, seeder/transplanter, reapers, thresher/shellers, combine harvesters, irrigation pumps were reported as 131700, 5400, 211300, 1600, 206700, 600, 4029400, 4586700 numbers respectively.

Singh (2006) estimated mechanization index and its impact on production and economics of crop production. A mechanization index based on the ratio of cost of use of machinery to the total cost of use of human labor, draught animals and machinery was selected for estimation. It was reported that although 78.5% farm power was contributed by mechanical sources, the average mechanization index was only 14.5%. The crop wise mechanization index varied from the lowest value 8.22% in sorghum and paddy crop production to 30% (highest value) in wheat crop. States having higher mechanization index incurred the lower cost of cultivation.

Kulkarni (2009) studied the scenario of mechanization of Indian agriculture and reported that tractors were being used in 20.27% of the total area for tillage and 21.30% of the total area for sowing operations. The levels of mechanization in different farm operation as reported is shown in Table 2.5.

Table 2.5 Level of Mechanization in India

Operations	Level of Mechanization (%)
1. Tillage	40.2
i. Tractor	15.6
ii. Animal	24.7
2. Sowing with drills and planter	28.9
i. Tractor	8.3
ii. Animal	20.6
3. Irrigation	37
4. Thresher	
i. Wheat	47.8
ii. Paddy and others	4.4

Singh and Mani (2009) conducted a study and estimated the levels of mechanization of various farm operations in India. The levels of mechanization for different farm operation were 40% for tillage, 30% for seeding/planting, 37% for irrigation, 48% for threshing of wheat and 35% for plant protection. The growth in farm machines from 1992 to 2003 was also reported and is presented below in Table 2.6

Table 2.6 Growth in Farm Machines in India

Tools/Machines	Period	
	1992	2003
Manual Operated	18634	40138
Animal Operated	89281	105811
Tractor/Power Operated	16910	25914
Total	124825	171863

Khambalkar et al. (2012) studied the requirement of farm mechanization at Central Demonstration Farm, Dr. PDKV, Akola. The power availability for the actual cultivable area was found to be 0.746 kW/ha, 0.291 kW/ha and 0.268 kW/ha for the year 2008-09, 2009-10 and 2010-11 respectively. The requirements of mechanization for the year 2009-10 for field operations ploughing, land preparation by the cultivator, crop intercultural, crop spraying and the sowing of the crop were 45.0%, 87.6%, 21.0%, 72.6%, 63.9% and 52.3% respectively. The requirements of mechanization for the year 2010-11 for operations like ploughing, land preparation by the cultivator, crop intercultural operations, crop spraying, sowing of the crop were 38.5%, 96.6%, 29.2%, 75.7%, 63.0% and 57.2% respectively. The farm machinery requirement was estimated using the following relationship

$$\text{FMR (\%)} = 100 - \left(\frac{\text{Actual area covered by machine (ha)}}{\text{Actual area under cultivation (ha)}} \times 100 \right) \quad \dots(2.1)$$

Where,

FMR= Farm machinery requirement

$$\text{No. of IR} = \frac{\text{UCA}}{\text{AFC} \times \text{No. of WD} \times \text{No. of WH}} \quad \dots(2.2)$$

Where,

No of IR= Number of implement required

UCA = uncovered cultivated area, ha

AFC = Actual field capacity, ha/h

No of WD= Number of working days

No of WH= Number of working hours

Narayanamoorthy et al. (2014) studied the effect of Mahatma Gandhi National Rural Guarantee Scheme (MGNREGS) on the mechanization of Indian agriculture. It was reported that a significant drop and scarcity of agricultural labor was observed after the introduction of MGNREGS among all states. It was concluded that use of agricultural machinery increased due to labour scarcity. The cost of cultivation of wheat and paddy crop increased after the introduction of the scheme.

Chauhan and Singh (2014) estimated crop specific mechanization diversities in India. A mechanization index based on the share of the cost of use of mechanical power operated farm implements over the total cost of use of human, animal, and mechanical power operated farm implement was estimated for analysis. A large diversity in mechanization for different crops at the state and national level was observed. Wheat crop recorded highest mechanization index of 40.77% at the country level whereas it was 56.17% Punjab. For paddy crop, it was 35.38% in Punjab whereas at national level 17.40% only. It was also reported that states having higher mechanization level recorded higher crop yield.

Mehta *et al.* (2014) reported the status of farm mechanization in India. The overall mechanization level of agriculture in India was only 40-45% even though 90% of total farm power was contributed by mechanical and electrical power sources. Operation wise level of mechanization was also reported in the study and it was 42% for seedbed preparation, 29% for seeding and planting, 34% for plant protection, 37% for irrigation and 60-70% for harvesting and threshing of wheat and rice.

2.3 Energetics of Wheat Crop Production

Mishra (1986) studied the energy consumption in the production of various crops under different tillage treatments. The treatments were selected according to the power source for the study. The power sources were bullock power with indigenous implements, bullock power with improved implements, 20 bhp tractor with matching implements and 35 bhp tractor with matching implements. Total energy consumptions for wheat crop were found 6606.28 MJ/ha for bullock power with indigenous implements, 5964.87 MJ/ha for bullock power with improved implements, 7569.73 MJ/ha for 20 bhp tractor with matching implements, 6588.98 MJ/ha for 35 bhp tractor with matching implements. The maximum saving of energy (40-61%) in seedbed preparation was obtained in the use of bullock power source with improved implements as compared to tractor power sources with matching implements. The higher horsepower tractor (35hp) consumed almost the same energy in seed bed preparation as the 20 bhp tractor. It was observed that the yield of the crops increased with increase in the level of energy input but the differences were not significant statistically.

Singh et al. (1997) studied the energy consumption pattern in Tarai and western region of Uttar Pradesh. Total energy consumption in the wheat crop was 6342, 6829, 6447 and 7708 MJ/ha for marginal, small, medium and large categories of farmers respectively in the region. Irrigation consumed maximum share (37.6%) of total energy input followed by seed bed preparation (24.09%) and threshing (22.45%). Sowing of wheat crop shared 6.6% of total energy.

Srivastava (2002) studied the source wise and operation wise energy use pattern in Punjab agriculture. It was reported that 54% energy in crop production was the direct source of energy like diesel, electricity, human power sources and animal power sources. The 46 % of energy was the indirect sources of energy like fertilizer, seed, agro-chemical, FYM and machinery. The study also indicated the decade wise increment in the share of different power sources in energy consumption in Punjab agriculture which is shown in Table 2.7.

Table 2.7 Percent Share of Different Power Sources in Punjab Agriculture

Source of Power	1980-81	1990-91	1999-00
Animate	2.9	1.7	1.3
Seed	5.4	4.0	3.1
Fertilizer & Chemical	36.3	33.6	30.2
Diesel	33.4	27.0	25.8
Electricity	22.0	33.7	39.6

The operation wise energy use pattern showed that irrigation consumes the highest share of energy (51%) among all operations followed by harvesting and threshing (19%), tillage (13%), sowing (2%) and fertilizers application (2%). Total energy consumption for wheat production was also reported for the different farming system. The study concluded that rain-fed farming was most economical and incurred only 6412 MJ/ha energy while irrigated farms consumed 19328 MJ/ha energy.

Gupta (2004) reported the energy consumption pattern in crop production in Tarai region of Uttarakhand. The study was based on information collected from farmers about each farm operation. The farms were categorized into two categories,

mixed farms and tractor farms as animal farms were not available in the region. Total energy consumption in wheat crop was found 15719 MJ/ha and 16309 MJ/ha for mixed and tractor farms respectively. In mixed farms, threshing of wheat incurred maximum amount of energy (1902 MJ/ha) followed by irrigation (1498 MJ/ha) and tillage (1415 MJ/ha). In tractor farms, threshing of wheat consumed maximum amount of energy (2441 MJ/ha) followed by tillage (1651 MJ/ha) and irrigation (1488 MJ/ha). Mixed farms were found more economical on the basis of energy consumption.

Chaudhary *et al.* (2006) carried out a study to assess the energy requirement for different cropping systems in Modipuram, Meerut, Uttar Pradesh. It was reported that rice-veg pea-wheat-greengram crop rotation consumed maximum energy (65052 MJ/ha) followed by rice-wheat (50264 MJ/ha). Pigeon pea- wheat system consumed minimum energy (29015 MJ/ha). Wheat crop consumed 21843 MJ/ha energy in which the share of fertilizer and diesel energy were 8340 MJ/ha and 8390 MJ/ha respectively.

De (2006) reported that chemical fertilizers incurred 45-47% of total energy consumption in wheat production in high yielding zone of Punjab, Uttarakhand and Western Uttar Pradesh. Diesel contributed 27% of total energy consumption. Electricity shared 12% of total energy for tractor farms and 24.5% of total energy for mixed farms. Irrigation operation required 31% of total operational energy. Tillage required 26% and 23% of total energy of mixed farms and tractor farms respectively. Sowing in tractor farms required 26.7% higher energy than mix farms due to use of tractor operated seed drill. Total energy consumption in wheat crop production was reported as 15554 MJ/ha.

Nassiri and Singh (2008) analyzed source wise and operation wise energy input in wheat crop production and optimized the inputs using DEA (Data Envelopment Analysis). Two basic DEA models, CCR (Charnes, Cooper and Rhodes) and BCC (Banker, Charnels and Cooper) were used to optimize the inputs. It was observed that crop yield was mostly dependent upon tillage, irrigation and sowing which had optimized share of 23%, 21.6%, and 17.4% for CCR model and 26.4%, 19.2% and 18% for BCC models respectively. It was also found that crop yield was sensitive to human, diesel and seed energy sources with optimized share of 32%,

18%, and 18.6% respectively for CCR model and 37%, 23.6% and 12.4% for BCC model respectively. Electricity and machinery possessed the highest use among all energy sources and it was reported to be 43.8% and 21.7% respectively for CCR model and 33.6% and 15.5% for BCC model respectively.

Khambalkar *et al.* (2010) studied energy and economic evaluation of farm operations in crop production. Agriculture operations into consideration were land preparation, sowing, irrigation, intercultural operations, harvesting and crop residue management. The results indicated that the operational energy requirement of traditional method and mechanized method as 1774.88 MJ/ha and 2736.46 MJ/ha for wheat crop, 2680.78 MJ/ha and 3130.72 MJ/ha for greengram crop and 4284.28 MJ/ha and 4336.41 MJ/ha for cotton crop respectively.

Ziaei *et al.* (2013) conducted a study to compare energy consumption and productivity of wheat and barley crop in order to prioritize crops planting in Sistan and Baluchistan province of Iran. The data were collected by interviewing the farmers. It was reported that total energy consumption for wheat and barley crop were 48517.24 MJ/ha and 49800.87 MJ/ha respectively and production of barley crop was more energy efficient from aspect of energy consumption compared to wheat crop in the region.

Aghapour *et al.* (2014) proposed the following relationship for the energy estimation by machine input

$$EID = \frac{TW \times CED \times h}{UL} \quad \dots(2.3)$$

Where,

EID= Indirect energy input of machinery, MJ/ha

TW= Total weight of machinery, kg

CED= Production energy consumed to manufacture machine, MJ/kg

h= Working hour of machinery per hectare

UL= Useful life of machinery, hour

2.4 Energy Saving Practices in Wheat Production System

Chaudhary and Singh (2002) studied the effect of zero, strip and conventional till system on the performance of wheat in a combine harvested rice field and manually harvested rice field. The study reported that zero till system saved fuel and time as compared to strip and conventional system. The saving of energy in irrigation for zero till was 34% and 47 % over strip till and conventional till system respectively. Fuel and time requirements for various treatments were reported which are shown in Table 2.8.

Table 2.8 Fuel and Time Required for Various Treatments in Wheat Production System

Treatments	Combine harvested rice field		Manually harvested rice field	
	Fuel consumption (l/ha)	Time Taken (h/ha)	Fuel consumption (l/ha)	Time Taken (h/ha)
Zero till sowing	5.34	1.60	5.31	1.54
Strip till sowing	16.37	3.87	13.85	3.04
Conventional till sowing	53.73	13.42	52.40	12.30

Gupta (2004) recommended the improved package of practices of implements and their required operations for wheat cultivation for mixed and tractor farms in medium yielding zone of Uttar Pradesh and are shown in Table 2.9.

Table 2.9 Packages for Improved Implements in Wheat Cultivation

Operation	Implement Package and Operations	
	Mix Farm	Tractor Farm
Seedbed preparation	Tractor drawn harrow×1 + Bullock drawn harrow ×3 + Bullock drawn Plank×2	Tractor drawn harrow×3 + Tractor drawn plank Or Tractor drawn rotavator×1

Sowing	Bullock drawn fertilizer drill	Tractor drawn fertilizer drill
Tillage+Sowing	Tractor drawn zero till ferti seed drill	Tractor drawn zero till ferti seed drill
Bund Making	Bullock drawn bund former + supported manually	Tractor drawn bund former + supported manually
Irrigation	Electric motor/Diesel engine operated tube well × 2-3 operations	Electric motor/Diesel engine operated tube well × 2-3 operations
Fertilizer application	manually×2	manually×2
Chemical application	Knapsack sprayer	Knapsack sprayer
Harvesting	Manually	manually
Threshing	Diesel/electric powered thresher or combine harvester	Diesel/electric powered thresher or combine harvester

De (2005) proposed a package of energy efficient implements for wheat cultivation in Punjab and compared it to the existing practices which is shown in Table 2.10.

Table 2.10 Energy Efficient Implements for Wheat cultivation in Punjab

Operations	Existing Practice	Energy Efficient Practice	Remarks
Seed bed preparation	Tractor drawn disc harrow and cultivator	Tractor drawn rotavator	Seed bed preparation by tractor drawn rotavator requires about 40-45% less time and 20-30% less energy as compared to harrow and cultivator without affecting the yield level.
Sowing	Seed cum fertilizer drill	Seed cum fertilizer drill	No change in energy level
Irrigation	Tube well/canal	Canal /Tube well with energy efficient accessories	Irrigation by canal saves 100% energy as compared to tube wells. Even the use of existing tube wells with proper maintenance and use of energy efficient valves and bends etc

			save about 10-15% energy.
Weeding	Khurpa-kasola	Wheel hand hoe/chemical weeding	Weeding by wheel hand hoe saves about 70% energy as compared with khurpa, 60% with kasola and 67% with chemical weeding
Harvesting/ Threshing	Manually by sickle and threshing by wheat thresher or by combine harvester	Harvesting by tractor drawn vertical conveyer reaper and threshing by thresher	Harvesting by combine harvester saves 40-45% energy as compare to manual harvesting

Dev and Bhandari (2014) studied the electricity consumption pattern for different pumps. The study concluded that use of BEE 5 star rating pumps can reduced electricity consumption up to 42% in irrigation. Study also indicated that large farmers capitalize cheaper sources like canals, rivers and energy efficient pumps while small farmers hire the implements from large farmers to irrigate their fields.

The forgoing review indicates that agriculture is an energy intensive system and crop yield significantly depends upon energy input in crop production. It has been observed that mechanization level of Indian agriculture is increasing with time. This increase in mechanization level demands more energy input such as fuel and electricity. Therefore, there is a need to carry out a systematic and integrated study of energy as a whole and its component in wheat crop production.



*Materials
and
Methods*



MATERIALS AND METHODS

A study was conducted to estimate the energy requirement in wheat crop production in district Udham Singh Nagar of Uttarakhand and adjacent area of Uttar Pradesh located in the Tarai region. Wheat is one of the major crops in rice-wheat crop rotation. The production agriculture practices in the region for different crops are highly mechanized at all farm levels. Over the years, it has been observed that mechanization level in Tarai region has changed significantly by adoption of higher horsepower tractors and different types of crop cultivation equipment. Therefore, in order to estimate the farm power availability, mechanization level and energy investment in wheat production in the region, the information from various categories of farmers was collected and data were analyzed.

3.1 Tarai Region of Uttarakhand

3.1.1 General information

Tarai region in India is situated at the outer foothills of Siwalik hill and north of the Indo-Gangetic plains. It starts from Chandigarh (foothill of Himachal hills), and lies in Doon Valley, Bijnore, Udham Singh Nagar, Rampur, Pilibhit, Gonda districts in India. Tarai belt is 15-25 km wide from North to South. Tarai region in Uttarakhand is located in Dehradun, Haridwar and Udham Singh Nagar districts. In Udham Singh Nagar, Tarai region lies between 28°53' and 29°20' north latitude and between 78°53' and 80°0' east longitude. Udham Singh Nagar is situated 383.39 m above mean sea level. Total geographical area of Udham Singh Nagar is 2908 km². Rice, wheat, sugarcane, mustard and peas are the major crops in the region. The common crop rotations followed in the Tarai region of Uttarakhand are continuous rice-wheat, rice-wheat-rice, sugarcane-ratoon-wheat or rice, rice-rapeseed-sugarcane-ratoon-wheat and rice-rice-peas. Total cultivable area of Udham Singh Nagar is 139350 ha. The total numbers of farmers are 103949. Table 3.1 shows the distribution of farmers in Udham Singh Nagar.

Table 3.1 Distribution of Farmers in U.S. Nagar

Marginal (< 1ha)	Small (1-2 ha)	Semi medium (2-4 ha)	Medium (4-10 ha)	Large (> 10ha)
63566	18277	14423	7155	528

3.1.2 Climate

The Tarai region has dry season from early-October to mid-June and wet from mid-June to early-October. Highest temperature occurs in May and June (42°C) and lowest in December and January (4°C). Relative humidity is highest in July (97%) and lowest in May (54%). The average rainfall is 1400 mm and most of it is received during monsoon between June to September.

3.1.3 Soils

The Tarai soils are mainly mollisols characterized by the presence of dry coloured surface having organic matter 1-4%. Soils texture varies from silty loam to clay loam (**Mishra, 1986**).

3.1.4 Selection of farmers

Total 226 farmers were contacted of 59 villages in 5 blocks of U.S. Nagar namely Bajpur, Gadarpur, Rudrapur, Sitarganj and Khatima block from and Rampur district of Uttar Pradesh as seen in Fig. 3.3. 95 farmers were surveyed from Rudrapur Block, 38 from Gadarpur, 22 farmers from Bazpur block, 42 farmers from Khatima block, 6 farmers from Sitarganj block of U.S. Nagar, 23 farmers were visited in Bilashpur block of Rampur district. Farmers were selected randomly in different blocks of U.S. Nagar in the Tarai region such that each farmer in population has equal probability to come under study.

3.1.5 Selection of crop

In the U.S. Nagar and adjoining villages which are located in the Tarai region, wheat is largely cultivated in the rice-wheat crop rotation. An attempt has therefore been made to study the selected parameters on wheat crop production including the use of agricultural inputs like seed, fertilizer, agrochemical, irrigation, machineries etc.

3.1.6 Collection of data

226 farmers from 59 villages in different categories were contacted during rabi season (February, 2016). The information on various aspects of wheat crop production in the region, farm power and machine use etc. was collected by personally interviewing the each selected farmer using a questionnaire as shown in Appendix A.



Fig 3.1 Tarai Region in India

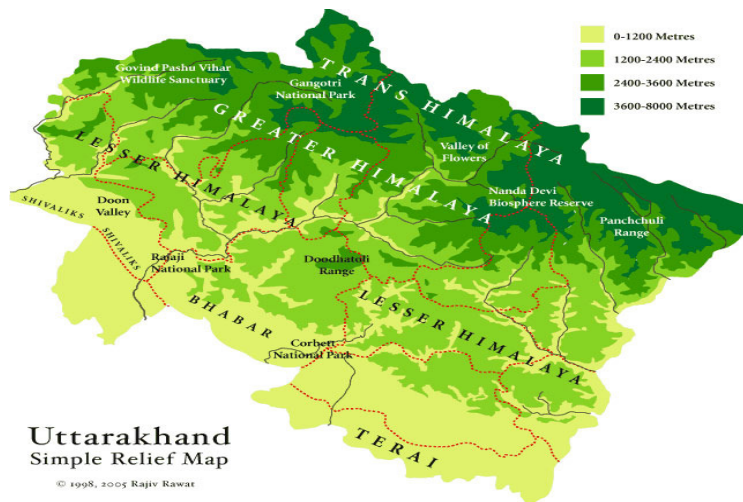


Fig 3.2 Tarai Region in Uttarakhand



Fig 3.3 Area surveyed in Udham Singh Nagar

3.2 Agricultural Inputs and Energy Co-efficient

In this study energy consumption was analyzed by obtaining information on use of vital agricultural inputs such as seed, fertilizer, agrochemicals, human labour, diesel and electricity consumption to determine direct and indirect energy use pattern in wheat crop production.

3.2.1 Direct sources of energy

The direct sources of energy are those that release energy directly to the crop production system. Human labour, animal power, fuel used to operate stationary and mobile power units such as engines, tractors, power tillers and electricity to operate electric motor fall under this category.

3.2.2 Indirect sources of energy

The indirect sources of energy are those that do not release the energy directly but some energy is invested in producing such energy sources. Energy of seeds, manures, agro-chemicals, chemical fertilizers and machinery are classified under this group.

It was thus necessary to identify the main farming inputs as used by different category of farmers as well as outputs. As discussed previously, operational energy involves direct energy sources and indirect energy sources. In this study direct energy consumption was analyzed on the basis of information on farm operations including tillage, sowing, irrigation, spraying, fertilizer application, intercultural operations, harvesting and threshing. Indirect energy that is used in preparation of seed, fertilizer, agrochemicals and machinery was also taken into account.

Table 3.2 shows the list of various direct and indirect energy sources used in wheat production system in the area and the different unit operations conducted using these energy sources.

In order to estimate the energy use in particular unit operation information on duration, amount and frequency of unit operations and energy inputs was collected and quantified using the energy co-efficient.

Table 3.2: Energy Sources used in Wheat Crop Production

Energy Sources	Unit Operations
Human power	Seed bed preparation, sowing, irrigation, inter-culture operation, harvesting and threshing
Diesel	Seed bed preparation, sowing, irrigation, interculture operation, harvesting and threshing
Electricity	Irrigation
Pesticide/weedicide	Intercultural operations and plant protection
Seed	Sowing
Fertilizer	Sowing/fertilizer application
Machinery	Seed bed preparation, sowing, irrigation inter culture operations, harvesting and threshing

3.2.3 Energy co-efficient

The total energy input was determined as the sum of input factors multiplied by the appropriate energy co-efficient for each factor as shown below (Gupta, 2004).

$$E = \Sigma (A_i \times C_i) \quad \dots (3.1)$$

Where,

E = energy input

A_i = input factors

C_i = energy co-efficient for input factor

The different energy inputs and appropriate energy co-efficient are shown in Table 3.3 (De, 2006).

Table 3.3 Energy Equivalents of Different Inputs

Sl.No.	Source	Unit	Energy equivalent (MJ)
1.	Human	Man-hour	1.96 1 adult women = 0.8 adult man 1 child = 0.5 adult men
2.	Animal	Pair-hour	10.10
3.	Diesel	Litre	56.31
4.	Electricity	Wh	16.93
5.	Seed	Kg	14.7
6.	FYM	Kg	0.3
7.	Fertilizer		
	N	Kg	60.6
	P		11.1
	K		6.7
8.	Agro chemical		120
	Inferior chemicals	Kg	100
9.	Machinery		
	Electric motors	Kg	64.80
	Prime mover		68.40
	Farm machinery		62.10

3.3 Estimation of Energy Input

3.3.1 Human energy

The human energy use was estimated by taking into account the hours of activity requiring labour and the number of labourers employed in that activity. Energy consumption was determined by multiplying the energy co-efficient of workers by the total hours of human activities in different unit operations.

3.3.2 Fuel

The main fuel input in agriculture is HSD (high speed diesel) which is used in tractors and irrigation pump sets. In order to estimate a reliable data on fuel consumption of tractors and pump sets as used by different categories of farmer, the following relationship was used (De, 2006).

$$F = \frac{LCF \times RHP \times SFC}{1000} \quad \dots (3.2)$$

Where,

F = fuel consumption, l/h

LCF = load co-efficient factor

RHP = rated horse power of source, kW

SFC = specific fuel consumption, ml/kWh

This approach was adopted to arrive at reliable information because of the reason that the information provided by the farmers on fuel consumption of different power sources was based on their estimate and without any proper record at their end.

The value of specific fuel consumption and rated horse power of various makes of tractor and combine harvester as used by the farmer of the region was obtained from the commercial test report of the respective tractor/ combine harvester published by CFMTTI and is shown in Table 3.4 and Table 3.5 respectively.

Table 3.4 Make of Common Tractors Used in Tarai region and Their Specific Fuel Consumption

Tractor		RHP (kW)	SFC (g/kWh)
Make	Model		
Mahindra	265DI	23.8	237
Escort	30	22.3	325
Sonalika	732	24.6	235
MesseyFerguson	1035 DI	26.1	230
Eicher	312	22.3	232
Swaraj	735	26.1	240
Mahindra	Arjun 445	26.1	243
Mahindra	475	26.1	240
Farmtrac	45	28.7	240

John Deere	5103	29.8	242
Swaraj	744 FE	29.8	250
Mahindra	555 Arjun	33.5	250
Farmtrac	60	31.6	249
Messey	241	29.8	249
Sonalika	750	32.8	263
Farm Trac	45	28.6	240
Hindustan	50	35.8	265
Standard	50	33.5	250
TAFE	45 PI	31.3	250
Same	50	33.5	250
Farmatrac	60	37.3	254
Mahindra	605 DI	41.0	263
Balwan	Tempo	37.3	255
Standard	325 DI	33.5	249
Mahindra	Bhumiputra	33.5	248
John Deere	5103	29.8	242
International	DI 750	37.3	255

Table 3.5 Make of Common Combine Harvesters Used in Tarai region and Their Specific Fuel Consumption

Combine Harvester	RHP (kW)	SFC (g/kWh)	Weight (kg)
Malkeet Nabha	79.4	329	6035
Kartar 4000	86.5	318	5790
Standard S 8300	75.3	329	6100

The values of load co-efficient factor for various powers are shown in Table 3.6 as proposed by De (2006).

Table 3.6 Load Coefficient Factor (LCF) for Different Unit Operations

Power source	Type of work	LCF
Stationary diesel engine	Water lifting	0.6
	Threshing etc.	0.8
Tractor	Light work e.g. transport, water lifting etc.	0.4
	Medium work e.g. secondary tillage, sowing intercultural operations etc.	0.5
	Heavy work e.g. primary tillage	0.6

3.3.3 Electricity consumption

Electric motors of different ratings were found to be used by different categories of farmers for irrigation purpose. The electricity consumption for an electric motor used by a farmer was estimated by the relationship proposed by De (2006).

$$E = RHP \times T \quad \dots (3.3)$$

Where,

E = electrical energy consumption, kWh

RHP = rated power of electric motor, kW

T = number of hours required for a particular operation, h

3.3.4 Fertilizer

Chemical fertilizers are most significant energy input in crop production. The chemical fertilizer such as urea, di-ammonium phosphate and NPK were found to be commonly used by farmers of the region in wheat production. The N, P and K content in different chemical fertilizer used by the farmer in the area was taken as N: 46% in urea and 18% in DAP. The phosphorus (P) content was taken as 46% in DAP, 32% in NPK. The potassium content in NPK was taken as 16%.

3.3.5 Chemical energy use

Phalaris minor, *Chenopodium album* and *Avena* are the major weeds in the region. The broadleaf weeds are controlled with 2, 4-D and *P. minor* with *Isoproturon* as a post emergence application after irrigation or occasionally *Pendimethalin* as a pre-emergence herbicide in the region. The study estimated the quantity of weedicides, herbicides, insecticide and fungicides needed to be sprayed. Table 3.7 shows the list of common weedicide used in the region and their recommended dose.

Table 3.7 Weedicides Used for Wheat Crop Production in Tarai Region

Sl. No.	Name of Weedicide	Recommend dose (ml/ha)
1.	Fenoxaprop-p-ethyl 10 cc	100-120
2.	Metsulfuronmethyle 20 W.P.	4
3.	2, 4-D 80% WP	500
4.	Carfentrozone 40 D.F.	60
5.	Clodinafop 15 WP	60
6.	Sulfosulfuron 75 WP	25
7.	Metribuzin 70 WUG	175-210

3.3.6 Machine energy

It is the sum of total energy consumed to manufacture machineries for different unit operations for crop production. Total energy of machine depends upon quantity of material used in its manufacturing. The machine energy has been calculated on the basis of energy conversion co-efficient and determined by the relationship as proposed by **Aghapour (2014)**.

$$ME = \frac{G.Mp}{T C_{ef}} \quad \dots (3.4)$$

Where,

ME = machine energy, MJ/ha

G = weight of the machinery, kg

M_p = energy use in machine manufacturing, MJ/kg

T = Machine economic life, h

C_{ef} = effective field capacity of machine, ha/h

The economic life of farm implements was taken according to **IS: 9164 (1979)** which is presented in Table 3.8.

Table 3.8 Economic Life of Agricultural Implements

Sl. No.	Name of Machine	Economic life (h)
1.	Stationary engine	10000
2.	Electric motor	15000
3.	Power tiller	8000
4.	Tractor	10000
5.	Combine	3000
6.	Seed drill	2500
7.	Seed cum fertilizer drill	2000
8.	Plough	3000
9.	Disc harrow	3000
10.	Cultivator	4000
11.	Power sprayer	2000
12.	Power thresher	2500
13.	Centrifugal pump	10000
14.	Rotavator	2400
15.	Agricultural trailer	3600

3.3.7 Operational time

The operational time interval in performing a unit operation is also an important factor to calculate human energy, fuel consumption, electricity consumption and machine energy for that particular operation. An attempt was made to calculate time of farm operations analytically, as observations provided by farmers was based on their estimation and was not actual. Operational time spent in a farm operation was calculated by using the relationship as proposed by **Mandal and Maity (2015)**.

$$\text{Operational time} = \frac{\text{Area under operation, ha} \times \text{No. of operation}}{\text{Theoretical field capacity} \times \text{Field Efficiency}} \quad \dots (3.5)$$

Table 3.9 shows the recommended field efficiency for different farm operations according to **IS 9164:1979**.

Table 3.9 Recommended Field Efficiency and Recommended Speed of Operation of Implements

Implement	Field Efficiency (%)	Recommended Speed (km/h)
Plough	80	4.5
Disc harrow	80	6
Cultivator	80	6
Seed drill	70	5
Seed-cum-fertilizer drill	70	5
Ridger	90	4.5
Rotavator	80	2.5
Combine (self-propelled)		
For paddy	75	2.0
For wheat	75	3.5

3.3.8 Theoretical field capacity of tillage implements

In order to calculate the theoretical field capacity, the specification of type of implement used by a particular farmer was obtained. The theoretical field capacity (TFC) of different implement was calculated as discussed below

3.3.8.1 Theoretical field capacity of disc harrow

The theoretical field capacity of a disc harrow is the product of its rated width and speed of operation. The rated width of a disk harrow used by farmers was calculated by using the relationships as stated in **IS 3606:1998**

$$W = \frac{0.95NS + 0.3D}{1000} \text{ for single action disc harrow} \quad \dots (3.6)$$

$$W = \frac{0.95NS + 0.6D}{1000} \text{ for double action disc harrow} \quad \dots(3.7)$$

Where,

W= Width of cut, m

N= Number of disc spacing

S= Disc spacing, mm

D= Diameter of disc, mm

$$\text{TFC of disc harrow} = \frac{\text{Rated width, m} \times \text{Speed of operation, km/h}}{10} \quad \dots(3.9)$$

3.3.8.2 Theoretical field capacity of a Seed cum ferti drill

TFC of a seed drill was calculated as below.

$$\text{Rated width of seed drill} = \text{Spacing between the tines} \times \text{No. of tines} \quad \dots(3.10)$$

$$\text{TFC of seed drill (ha/h)} = \frac{\text{Rated width, m} \times \text{Speed of operation, km/h}}{10} \quad \dots(3.11)$$

3.3.9 Energy in irrigation

In order to estimate the energy consumed in irrigating the wheat crop in the region, it was found that almost all farmers use the surface irrigation method. In this method normally subsurface water is lifted using a pump driven by diesel engine/electric motor or canal water is used. For estimation of energy, information on the number of recommended irrigation, height of water level in each irrigation in field, area of field, prime mover size and discharge of the pump were obtained. The time spent in irrigating the unit area of field was estimated using the relationship as proposed by **FAO**.

$$t = \frac{A \times h}{Q \times \eta} \quad \dots(3.12)$$

Where,

t = Time of operation, h

A = Area under operation, ha

h = Recommended height of water in field, m

Q = Discharge of irrigation pump, m³/s

η = Conveyance efficiency, %

Normally in Tarai region, 2-3 number of irrigations each of 60-70 mm height are recommended (**Krishak Vagyanik Sanvad Patrika, 2015**). Table 3.10 shows the recommended value of field conveyance efficiency for different irrigation methods (**FAO**) adopted by farmers.

Table 3.10 Field Conveyance Efficiency for Different Irrigation Methods

Irrigation Method	Field Conveyance Efficiency (%)
Surface irrigation	60
Sprinkler Irrigation	75
Drip Irrigation	90

3.3.10 Energy in harvesting and threshing

In the Tarai region of Uttarakhand, farmers in all categories cultivating wheat, get the crop harvested by a combine harvester. The theoretical field capacity of a combine harvester was determined by using the relationship.

$$\text{TFC (ha/h)} = \frac{\text{Rated width of combine, m} \times \text{Speed of operation, km/h}}{10} \quad \dots(3.13)$$

3.4 Computation of Total Energy Consumption

The total energy consumption in a farm operation is the sum of human energy, animal energy, fuel, electricity, seed energy, fertilizer energy, machine energy and agro chemical energy. An attempt was made to analyze the data for each farm operation for each farmer using the following expressions.

$$\text{Human energy} = \sum_{i=1}^n h_i x_i$$

$$\text{Animal energy} = \sum_{i=1}^n a_n x_i$$

$$\text{Fuel energy} = \sum_{i=1}^n d_i x_i$$

$$\text{Electrical energy} = \sum_{i=1}^n e_i x_i$$

$$\text{Seed energy} = \sum_{i=1}^n s_i x_i$$

$$\text{Fertilizer energy} = \sum_{i=1}^n F_i x_i$$

$$\text{Machine energy} = \sum_{i=1}^n m_i x_i$$

$$\text{Chemical energy} = \sum_{i=1}^n c_i x_i$$

$$\text{Total energy} = \sum_{i=1}^n t_i x_i$$

$$t_i = h_i + a_n i + d_i + e_i + F_i + s_i + m_i + C_i \quad \dots(3.14)$$

where h_i , $a_n i$, d_i , e_i , F_i , s_i , m_i and C_i are human energy animal energy, fuel energy, electrical energy, fertilizer energy, seed energy, machine energy and chemical energy, respectively for each farm, operation.

3.4.1 Energy productivity

Energy productivity is a measure of energy efficiency of crop production system. It is defined as ratio of crop yield to the total energy input. Energy productivity of wheat crop production system was obtained by following relationship as proposed by **De (2005)**

$$\text{Energy Productivity, kg/MJ} = \frac{\text{Crop Yield, kg/ha}}{\text{Total Energy Input, MJ/ha}} \quad \dots(3.15)$$

3.4.2 Energy Ratio

Energy ratio of crop production system is the ratio of output energy to the input energy and obtained by the following relationship.

$$\text{Energy Ratio} = \frac{\text{Total Energy Output, MJ/ha}}{\text{Total Energy Input, MJ/ha}} \quad \dots(3.16)$$

3.5 Level of Mechanization

Level of mechanization of a region is normally indicated by farm power availability, availability of farm implements and mechanization index. These parameters were calculated to define the status of farm mechanization in the Tarai region.

3.5.1 Farm power availability

The key factor of farm mechanization is availability of power source. In Indian agriculture the different sources of farm power can be classified as mobile power sources and stationary power sources. Mobile power sources include human power, draught animals, tractors, power tillers and self propelled machines like reapers, combine harvesters etc. Stationary power sources include diesel engines and electric motors.

Farm power availability per hectare was calculated by using the following relationship (**MOAFW, 2014**).

$$\text{FPA, kW/ha} = \frac{(\text{No. of Agri. workers} \times 0.05) + (\text{No. of draft animals} \times 0.3) + (\text{Sum of RHP of tractor}) + (\text{Sum of RHP of power tillers}) + (\text{No. of electric motors} \times \text{RHP}) + (\text{No. of diesel engines} \times \text{RHP})}{\text{Avaialablecultivableland, ha}} \quad \dots(3.17)$$

Where,

FPA= Farm power availability, kW/ha

3.5.2 Farm mechanization index

Mechanization index represent the ratio of work done by machinery to the total work done by human, draft animals and machinery in percentage. Farm mechanization index was calculated by relationship as proposed by **Nowacki (1974)**.

$$\text{MI} = \frac{\text{LM}}{\text{LT}} \times 100\% \quad \dots(3.18)$$

Where,

$$\begin{aligned} \text{MI} &= \text{Mechanization index} \\ \text{LM} &= \text{Average sum of all mechanical work of the machine, MJ/ha} \\ \text{LT} &= \text{LM} + \text{LH} + \text{LA} \end{aligned} \quad \dots (3.19)$$

Where,

$$\begin{aligned} \text{LH} &= \text{Sum of work done by human, MJ/ha} \\ \text{LA} &= \text{Sum of work done by draft animal, MJ/ha} \end{aligned}$$

3.5.3 Availability of farm machinery

The details of inventory of all the farm equipments like hand tools, tractor operated and self-propelled equipments was obtained from farmers. The requirement of farm implements was calculated by the relationship as proposed by **Khambalkar (2012)**.

Farm machinery demand supply gap= No of available machine- No. of required machine

$$\text{Number of IR} = \frac{\text{UCA}}{\text{AFC} \times \text{No. of WD} \times \text{No. of WH}} \quad \dots (3.20)$$

Where,

$$\begin{aligned} \text{No. of IR} &= \text{No. of implement required} \\ \text{UCA} &= \text{Uncovered cultivated area, ha} \\ \text{AFC} &= \text{Actual filed capacity, ha/h} \\ \text{No. of WD} &= \text{Number of available working days for the prescribed time} \\ &\quad \text{window of the crop} \\ \text{No. of WH} &= \text{Number of working hours per day, h/d} \end{aligned}$$

Working hours per day were taken as 8 hours. The time window used was based on the chart for different operations on wheat crop as validated for the Tarai region. Table 3.11 shows the time window for different unit operations in wheat crop production system of Tarai region. The time window does not have any mention for irrigation and fertilizer application and normally these operations are done by farmer as and when needed.

The farm machinery availability with a particular farmer was obtained by taking the difference between number of implements available with farmer and number of implement required. An adequacy on availability of equipment was estimated taking a zero value indicating that the farmer has adequate number of equipments. A positive value indicates the farmer has more number of equipments than required and a negative value indicates that farmer does not have adequate number of equipments.

Table 3.11 Time Window for Different Unit Operations in Wheat Crop Production

Unit Operation	Month	Day Available for Operation
Seedbed Preparation	November	15
Sowing	November	15
Spraying	January	30
Harvesting	April	15

3.6 Analysis of Data

The data collected from each farmer were transferred into MS Excel data sheet for each operation. The individual farmer wise following information was used:

- i. Source wise input energy use, MJ/ha
- ii. Operation wise input energy use, MJ/ha
- iii. Area of farm, ha
- iv. Inputs as seed, FYM, nitrogen, phosphorus and potassium fertilizers, kg/ha
- v. Use of man, women, animal, tractor, power tiller, combine harvesters, electric motors as well as diesel engine driven pump sets, h/ha
- vi. Implements/machinery used with each power source, h/ha

3.7 Examination of data

In the processes where sample size is more than 30, outlier points have been identified adopting the process discussed in Section 3.7.1 to minimize the error in dataset.

3.7.1 Identification of outlier points

In the process of data collection through survey using a questionnaire, a scope exists to review the data for detection of outlier or extreme points i.e. a data point which appears to be away from the pattern of whole data for minimizing the error

Outlier data were identified using Z score method at 97.5% level of confidence. Any observation having Z score less than -3 and greater than +3 were considered as outlier. Z score of a data set is calculated by following relationship.

$$Z = \frac{X - \mu}{SD} \quad \dots(3.21)$$

Where,

X= Value of the observation

μ = Mean of the data set

SD= Standard deviation of the data set.

3.7.2 Central tendency of data

The above method was adopted to determine farm power availability in area. To compute the mean of total population of the region, weighted average method has been used considering the population of farmers for different categories in the region.

$$\text{Mean of variable } (\bar{X}) = \frac{N_1\bar{X}_1 + N_2\bar{X}_2 + N_3\bar{X}_3 + N_4\bar{X}_4 + N_5\bar{X}_5}{N_1 + N_2 + N_3 + N_4 + N_5} \quad \dots(3.22)$$

Where,

$\bar{X}_1, \bar{X}_2, \bar{X}_3, \bar{X}_4$ and \bar{X}_5 are the mean of a variable of marginal, small, semi medium, medium and large category farmers.

N_1, N_2, N_3, N_4 and N_5 is the population of marginal, small, semi medium, medium and large category farmer in the region.



*Results
and
Discussion*



RESULTS AND DISCUSSION

A study was undertaken with the objective to estimate, farm power availability, level of mechanization and an energy consumption pattern in wheat crop production system in Tarai region of Uttarakhand. Total cultivable area of Tarai region is 139350 ha. The total number of farmers in Tarai region of Uttarakhand are 103949 in which 63566, 18277, 14423, 7155 and 528 farmers belong to the marginal, small, semi-medium, medium and large category respectively. Rice-wheat, sugarcane-ratoon-wheat, rice-rice- pea are the common cropping patterns in the region. The cropping intensity of rice-wheat cropping system is 200%. Total 95515 ha area is under wheat cultivation in Udham Singh Nagar. The findings of the study are discussed in this chapter. It includes farm power availability, the level of mechanization, energy consumption and energy productivity in wheat crop production in the region.

4.1 Farm Power Availability

The farm power availability of the region was calculated by the method described in Section 3.5.1. The data for farm power availability of large, medium, semi-medium, small and marginal categories of farmer are presented in Table B-1 to B-5 respectively. The data presented in above tables indicate that the number of large, medium, semi medium, small and marginal farmer contacted during the study were 45, 47, 49, 41 and 40 respectively. The data further indicate that out of 45 large farmers, 13 farmers have more than one tractor. Three farmers in medium category out of 47 had more than one tractor. In semi medium category only 32 farmers owned tractor out of 49, whereas only 16 farmers in small category had their own tractors for farming. It was also found that out of 40 marginal farmers 6 farmers having their own tractors. The data also show that the average size of tractor with the large, medium, semi medium, small and marginal farmers was 36.5, 31.7, 31.4, 30.5 and 24.2 kW respectively.

The tables B-1 to B-5 indicate that in case of few farmers in all the categories, there is a large deviation in tractor power availability which may increase an error of estimation therefore a Z-score method was adopted for removal of extreme point as

discussed in Section 3.7.1. Any observation having Z-score value greater than +3 and lower than -3 was removed from the data set.

4.1.1 Farm power availability of large farmers

The degree of mechanization amongst the large farmers of Tarai region of Uttarakhand is very high. The large farmers in the region generally have high horsepower tractors, number of diesel engines/electric motors driven pump sets and some are having combine harvesters. Out of 45 large farmers contacted, the observations for three farmer (number 2, 8 and 20) were found significantly away from the pattern of the data having Z-score lesser than -3 and four farmers (number 14, 23, 24 and 30) having the Z score value more than +3 (Table B1). These seven farmers were removed from the dataset and mean from the remaining observations was calculated. The total availability of farm power for large farmers which includes human power, tractor power and power availability from electric motor, diesel engine and combine harvesters has been estimated as 3.14 kW/ha.

4.1.2 Farm power availability of medium farmers

It was observed from calculation of Z-score of the data set that farmer number 3, 7, 8, 17, 20, 22, 23, 27, 31, 37, 38 and 43 have the Z-score value greater than +3 and farmer number 5, 21, 29, 36, 42, 44 and 45 (total 19 farmers) out of 47 farmers have the Z-score value lesser than -3 so these points were considered as the outlier points which can significantly affect the mean of the data set and therefore removed from dataset. (Table B2)

The higher farm power availability (4.11 kW/ha) was observed for the farmers of medium category may be due to the reason that average tractor power size with them was 31.7 kW whereas it was 36.5 kW with large farmers. The observed data also indicate that farmers of medium category has much lower land holding compared to large farmers whereas size of tractor, electric/diesel engine driven pump sets owned by them either similar or close to the large farmers.

4.1.3 Farm power availability of semi medium farmers

The extreme point of the observations was calculated by Z-score method. It was found that farmer number 1, 3, 4, 5, 6, 10, 11, 12, 13, 14, 17, 18, 22, 23, 24, 25,

26, 27, 28, 31, 34, 37, 39, 40, 41 and 47 (total 26) were showing the Z-score variation greater than +3 out of 49 farmers so these observations were discarded from the data set (Table B3). Based on the analysis of data, the farm power availability of semi-medium farmer was estimated as 2.70 kW/ha.

4.1.4 Farm power availability of small farmers

Small farmers in the region generally hire machineries and power sources from large and medium scale farmers. The extreme points from the data set were discarded using Z-score method. Farmer number 5, 8, 11, 13, 14, 16, 17, 18, 19, 21, 23, 26, 28, 33, 34 and 36 (total 15 farmers) out of 41 farmers have the Z-score greater than +3 so these points were removed from the dataset (Table B4). The analysis of data revealed that average farm power availability for small farmers is 2.10 kW/ha.

4.1.5 Farm power availability of marginal farmers

Marginal farmers in the region usually do not have any tractor or other power sources. Marginal farmers generally hire the machineries from large and medium farmers. Farmer number 4, 6, 7, 10, 16, 25, 26, 28, 31, 33 and 34 (total 11 farmers) out of 40 farmers have the Z-score value greater than +3 and discarded from the data set (Table B5). Thus the farm power availability of marginal farmers was found 1.65 kW/ha.

4.1.6 Total farm power availability in Tarai region

Agriculture in Tarai region of Uttarakhand is highly mechanized and has high farm power availability. In order to estimate the total farm power availability amongst different categories of farmer, the weighted mean of farm power availability was estimated by taking total population of farmers of different category into account. The overall farm power availability of the region is thus calculated and presented in Table 4.1.

It is evident from the table that average farm power availability in Tarai region of Uttarakhand is 2.05 kW/ha. The past research indicates that the farm power availability during 2001 in Uttaranchal was 1.6 kW/ha against 1.35 kW/ha in India. The farm power availability in India during 2013-14 was 2.02 kW/ha as reported by **Singh, (2014)**. Further, the productivity of wheat crop in Tarai region of Uttarakhand

is comparable with Punjab where the present farm power availability is 5.68 kW/ha in the year 2012-13 (Mehta 2013).

Table 4.1 Total Farm Power Availability of Tarai Region of Uttarakhand

Type of Farmer	No. of Farmers in the Region	Farm Power Availability, (kW/ha)
Large	528	3.13
Medium	7155	4.11
Semi Medium	14423	2.7
Small	18277	2.1
Marginal	63566	1.65
Weighted Average		2.05

It has also been observed that in the Tarai region some large farmers (28.9%) possess more than one tractor. Also some large farmers (26.7%) have more than one electric motor operated pump sets and 42.4% large farmers have diesel engine operated pump sets. These farmers have land in different locations and therefore they possess more than one pump sets.

4.2 Mechanization Index

Agriculture in Tarai region of Uttarakhand is highly mechanized. Almost all farmers use tractor power for different unit operations in wheat crop production. An energy based mechanization index was calculated for each unit operation in wheat crop production for different category of farmers by the method described in Section 3.5.2. The mechanization index for each unit operation conducted by different categories of farmer in wheat production system in Tarai region was calculated and presented in Table C-1 to C-6.

4.2.1 Mechanization index for tillage operation

Mechanization index for harrowing operation was calculated and presented in Fig 4.1. Almost all farmers in all categories use tractors for seed bed preparation in the region. The farmers, who do not own a tractor, hire tractor for seedbed

preparation. The farmers use 7×7, 8×8, 9×9 size disc harrows for tillage in the region. The results indicate that the average mechanization index of harrowing in the region is 97%, 97%, 97%, 96% and 96% for large, medium, semi-medium, small and marginal categories respectively. The mechanization index for tillage operation shows the similar trend for all categories of farmer as they use tractors and trailed type disc harrow for seed bed preparation.

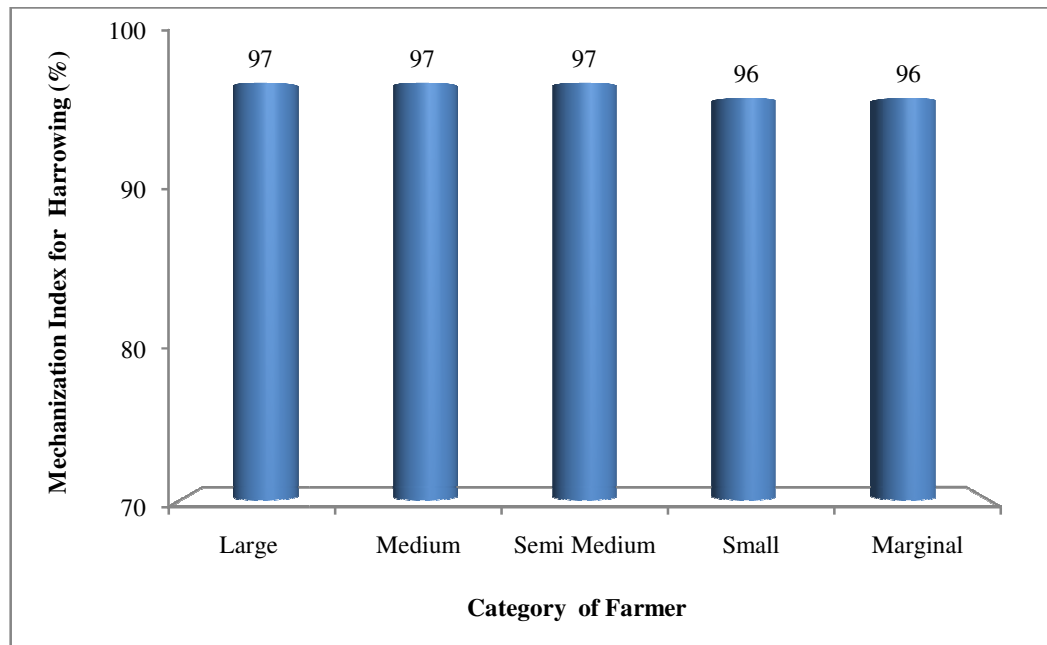


Fig. 4.1 Mechanization Index for Harrowing Operation

4.2.2 Mechanization index for planking operation

All farmers in Tarai region in all categories use tractor power for planking operation. The mechanization index for planking operation was estimated and presented in Fig 4.2. The study revealed that the mechanization index in the region for planking operation is 96%, 94%, 94%, 93% and 92% for large medium, semi-medium, small and marginal category, respectively. It was observed that the mechanization index of planking operation is also very high because all farmers use tractor power for planking operation. Small and marginal farmers who do not have a tractor generally hire tractor from the large and medium farmer for conducting planking operation. A little lesser mechanization index in planking of small and marginal farmer is due to the fact that the number of planking operations conducted

by them is less (2-3 operations) than the operations conducted by large, medium and semi-medium farmers (4-5 operations).

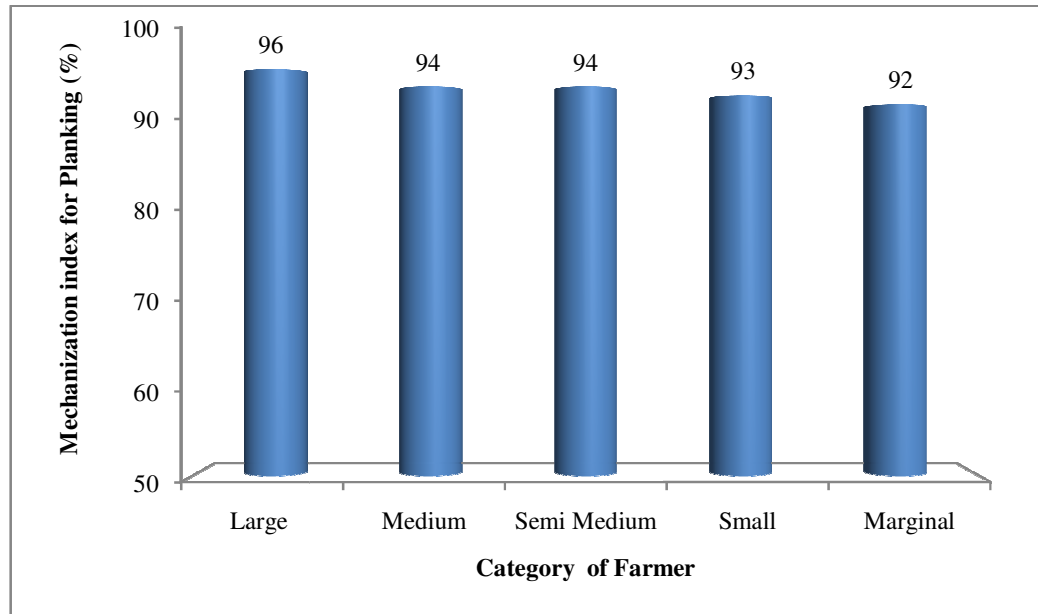


Fig 4.2 Mechanization Index for Planking Operation

4.2.3 Mechanization index for sowing operation

The farmers in Tarai region generally use seed cum ferti drill for sowing operation. Some farmers in small and marginal categories broadcast the seed for sowing operation. An energy based mechanization index for sowing operation was calculated which is presented in Fig 4.3.

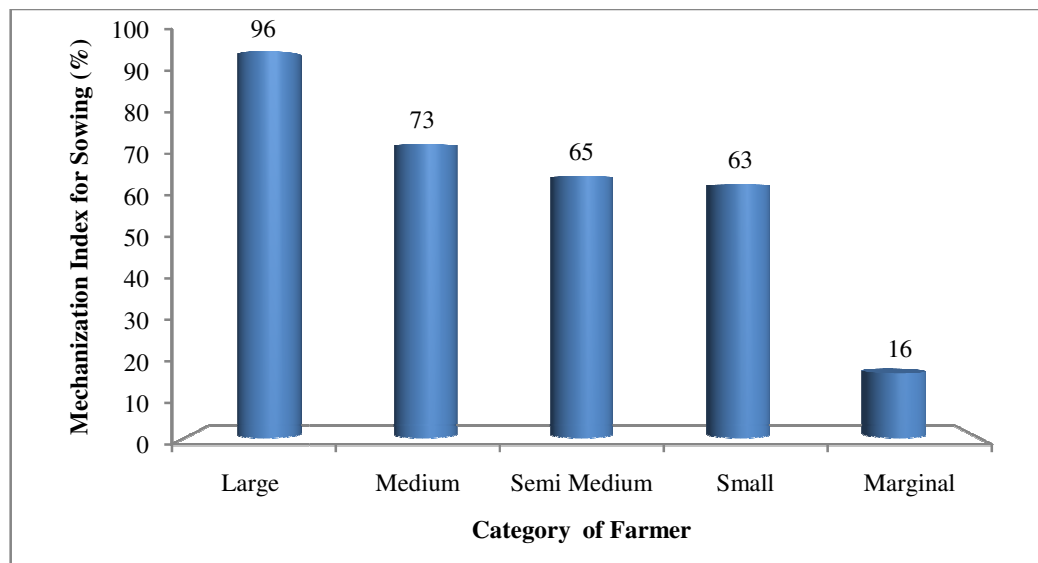


Fig 4.3 Mechanization Index for Sowing Operation

The mechanization index for large, medium, semi medium, small and marginal farmers was found as 93%, 75%, 65%, 63% and 16%, respectively. The results show that mechanization index for the sowing of wheat crop is very high for large farmers. Average 23% farmers of medium category do not use seed cum ferti drill and therefore mechanization index is 75%. It has also been observed that mechanization index in the sowing operation is gradually reducing from medium to small farmers. This is due to the fact that 25 % farmers in semi medium category, 28.5% farmers in small category and 80% farmers in marginal category generally broadcast the seed for sowing, hence the mechanization index for sowing of wheat has been found very low for them.

4.2.4 Mechanization index for irrigation operation

All farmers in Tarai region use surface irrigation method in wheat cultivation for irrigating the fields. Electric motor and diesel engine driven pump sets are commonly used for irrigation in the region. In some villages of Udham Singh Nagar, canal and artisan tube wells are also available. In order to estimate the mechanization index of irrigation, the farmer using different mode of irrigation as shown in Table B1-B5 were identified and shown in Table 4.2.

Table 4.2 Status of Available Irrigation Source in Tarai Region of Uttarakhand

Category of Farmers	Mode of Irrigation		
	Electric Motor Pump sets	Diesel Engine Pump sets	Canal
Large	34	30	11
Medium	16	28	15
Semi Medium	23	19	23
Small	18	11	18
Marginal	12	04	15

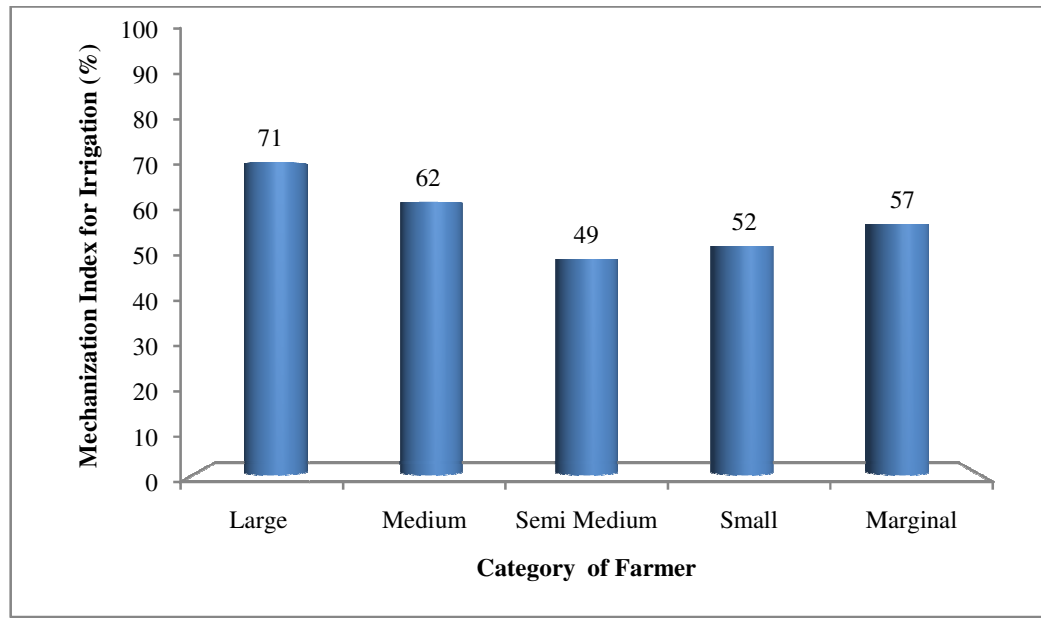


Fig 4.4 Mechanization Index for Irrigation Operation

The status of mechanization index for irrigation operation is presented in Fig 4.4. The study revealed that average mechanization index for large, medium, semi-medium, small and marginal categories has been found as 71%, 62%, 49%, 52% and 57%, respectively. It was observed that 24.4% of large, 31.9% of medium category, 46.9% of semi medium, 42.8% of small and 36.5% of marginal category farmers use canal water or artisan wells for irrigation where no mechanical energy is required. Since, a large number of farmers in all categories have access to canal water, therefore mechanization index in irrigation has been found low. However, mechanization index for all categories of the farmer who use diesel pump set/ electric motor operated pump sets for lifting irrigation water has been found to lie in the range of 85% to 98% as evident from the Table C4.

4.2.5 Mechanization index of plant protection

In Tarai region, weed control in the wheat crop is commonly done by application of weedicides using either manually or power operated sprayers. Generally, large and medium farmers use tractor pto operated power sprayers in the region while small and marginal farmers use manually operated knapsack sprayers for application of agrochemicals in wheat crop. Some farmers also use power operated knapsack sprayer. Average mechanization index of spraying operation is presented in Fig 4.5.

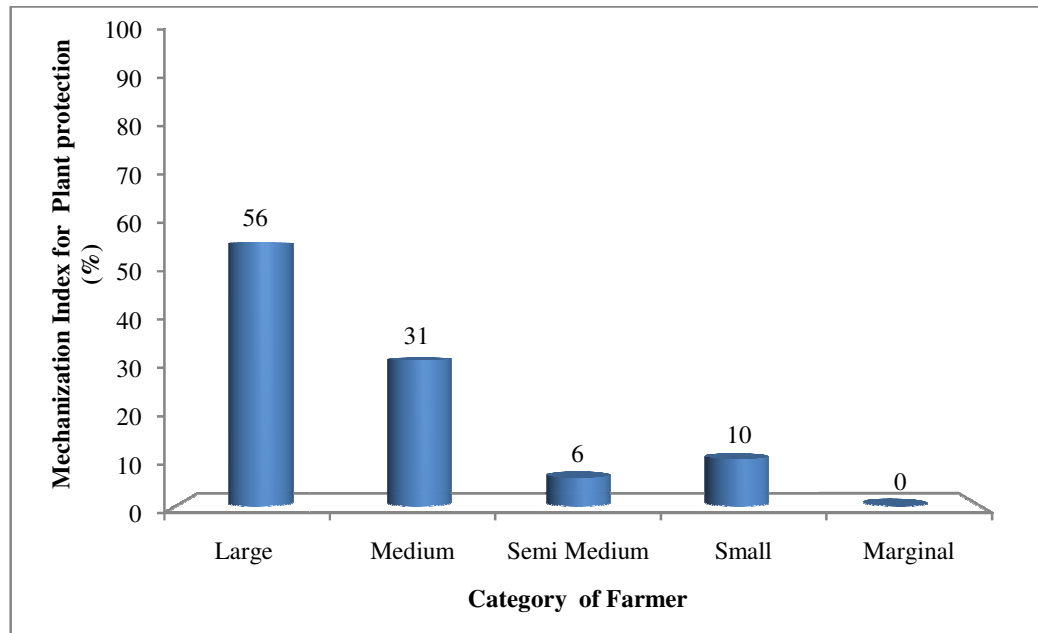


Fig. 4.5 Mechanization Index for Plant Protection Operation

The results indicate that average mechanization index for spraying operation was found to be 56%, 31%, 6%, 10%, and 0% for farmer of large, medium, semi-medium, small and marginal categories, respectively. In large category of farmers, 46.7% farmer use tractor pto operated power sprayer, 24.4% farmers use power operated knapsack sprayer and 28.8% farmers use manually operated knapsack sprayer in spraying. In medium category, 25% farmers use tractor pto operated power sprayer, 12.5% farmers use power operated knapsack sprayer and 62.5% farmers use manually operated knapsack sprayer. Similarly, in semi medium category, 6% farmers use power operated knapsack sprayer and 94% farmer use manually operated knapsack sprayer. It has also been found that in small farmer category, 14.3% use power operated knapsack sprayer and 85.7% farmers use manually operated knapsack sprayer. All farmers in marginal category use manually operated knapsack sprayer where no mechanical energy is involved therefore the mechanization index of the marginal farmer has been observed to be 0%.

4.2.6 Mechanization index of harvesting and threshing operation

Combine harvesters are largely used by the farmers of Tarai region for the harvesting of the wheat crop. Some of the large farmers in the region own combine harvesters. Other farmers in the region hire combine harvesters from large farmers or harvesters available on custom hiring basis. It has been also found that some medium

and small farmers harvest the crop manually and thresh it by using a power thresher. Average mechanization index of harvesting and threshing operation for Tarai region is presented in Fig 4.6. The average mechanization index for harvesting and the threshing operation was found 90%, 90%, 88%, 87% and 89% for large, medium, semi medium, small and marginal categories, respectively.

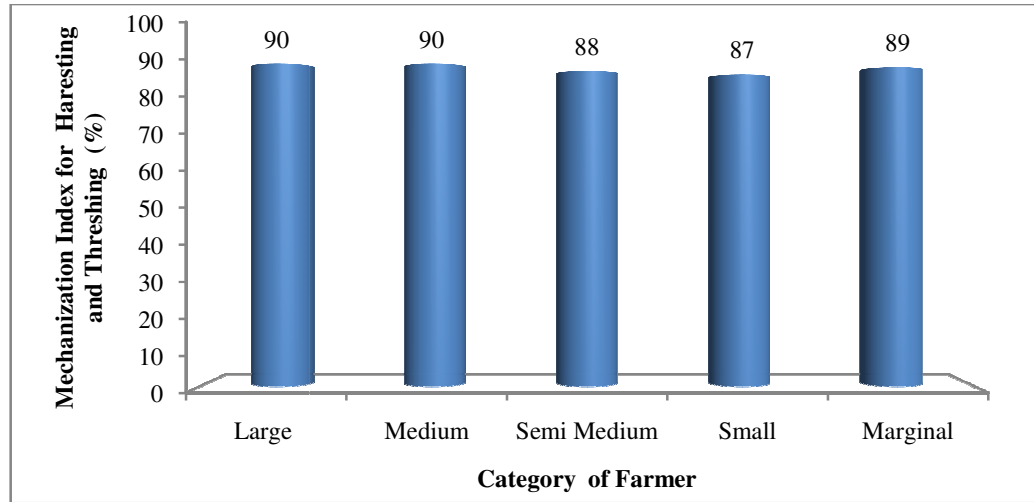


Fig 4.6 Mechanization Index for Harvesting and Threshing Operation

The forgoing results indicate that the mechanization index in Tarai region of Uttarakhand in wheat production system for the unit operation like harrowing, planking, harvesting and threshing is almost similar between all categories of farmer. However, the mechanization index for other operation amongst the semi medium, small and marginal farmers is low as these farmers employ human labour largely for these operations. The past studies indicate the mechanization index for India is 40% for tillage, 30% for sowing, 37% for irrigation, 48% for harvesting and threshing and 29% for plant protection (**Singh and Mani, 2009**). Based on the above results it can be stated that mechanization index in Tarai region of Uttarakhand is higher than the mechanization index at national level.

4.3 Farm Machinery Demand Supply gap in Wheat Crop Production

Farm machinery demand-supply gap in wheat crop production in Tarai region of Uttarakhand was calculated according to method discussed in Section 3.5.3. Farm machinery demand-supply gap in different operation for different category is presented in Table D1 to D4. Table 4.3 shows the number of farmers having more, less or adequate number of implements for different unit operations in wheat crop production in Tarai region of Uttarakhand.

Table 4.3 Adequacy of Number of Agricultural Equipments for Different Unit Operations in Wheat Crop Production

Category of Farmers	Adequacy of Implement Available	Number of Farmers			
		Seedbed Preparation	Sowing	Plant Protection	Harvesting and Threshing
Large	More	36	37	34	5
	Adequate	1	0	1	0
	Less	8	8	10	40
Medium	More	40	20	30	3
	Adequate	0	0	0	0
	Less	8	29	18	45
Semi Medium	More	36	7	19	6
	Adequate	0	1	3	0
	Less	13	41	27	43
Small	More	17	5	22	5
	Adequate	3	0	3	0
	Less	22	37	17	37
Marginal	More	5	0	3	0
	Adequate	0	0	0	0
	Less	35	41	38	41

It has been observed from Table 4.3 that in 80.0% of large, 83.3% of medium, 73.5% of semi medium, 40.5% of small and 12.5% of marginal farmers have more than required implements for seed bed preparation while 17.8% of large, 16.6% of medium, 26.5% of semi medium, 52.4% of small and 87.5% of marginal farmers do not have sufficient number of implements for seed bed preparation.

For sowing operation, 82.2% of large, 41.8% of medium, 14.3% of semi medium, 14.6% of small and 0% of the marginal farmers own more than sufficient implements while 17.8% of large, 59.2% of medium, 83.7% of semi medium, 85.4%

of small and 100% of marginal farmers do not own sufficient implements for sowing. All marginal farmers and a large number of small and semi medium farmers also sow wheat crop through broadcasting therefore the percentage is high and even some cases the farmer who do not own a seed drill usually hires it at the time of sowing.

Similarly, in plant protection, 75.6% of large, 62.5% of medium, 38.8% of semi medium, 52.4% of small and 7.3% of marginal farmers own more than sufficient implements while 22.2% of large, 37.5% of medium, 55.1% of semi medium, 40.5% of small and 92.7% of marginal farmers do not own sufficient implements for plant protection. Most of the marginal farmers hire the manually operated knapsack sprayer for application of agro-chemicals.

In harvesting and threshing operation, 11.1% of large, 6.3% of medium, 12.2% of semi medium, 11.9% of small and 0% of marginal farmers own more than sufficient equipments while 88.9% of large, 93.7% of medium, 12.2% of semi medium, 88.1% of small and 100% of marginal farmers do not own sufficient implements for harvesting and threshing operation. A large number of farmers in large, medium and small category opt for combine harvesting of wheat crop and therefore do not own any harvesting and threshing equipment.

4.4 Energy Consumption in Wheat Crop Production

A study was also undertaken to estimate the energy consumption pattern in wheat crop production in Tarai region of Uttarakhand. Operation wise as well as source wise energy requirement in wheat crop production and their percent distribution on the basis of total energy has been analyzed and presented in Table E1 to E7.

4.4.1 Operation wise energy consumption in wheat crop production

The energy requirement for each unit operation in wheat crop production was analyzed for each category of farmer as discussed in Section 3.3.

4.4.1.1 Energy consumption in tillage operation (Harrowing)

In Tarai region of Uttarakhand farmers in all categories use 7×7, 8×8 and 9×9 trailed type disc harrow for seed bed preparation in wheat crop. Energy consumption in tillage operation was analyzed for different farmer categories. The total energy

consumption for tillage operation (harrowing) is presented in Fig 4.7. The total energy consumption for tillage operation has been found to be 2602.3, 2182.4, 2020.6, 1461.3, 1284.2 MJ/ha for large, medium, semi-medium, small and marginal categories of the farmer, respectively. The large and medium category farmers have high horse power tractors and they generally perform more (5-6 or even more) operations than other category of farmers and therefore energy consumption of large and medium category farmers was found to be greater than farmers of other category. Farmers of small and marginal category generally hire tractors and implements from other category of farmers and perform lesser number of operations (2-3) to reduce their cost of cultivation therefore the energy consumption of small and marginal category farmer was found lesser than farmers of other categories. It has been also found that 17.8 % of large farmer use rotavator to prepare the seedbed which consumes 2006.1 MJ/ha of energy in seedbed preparation.

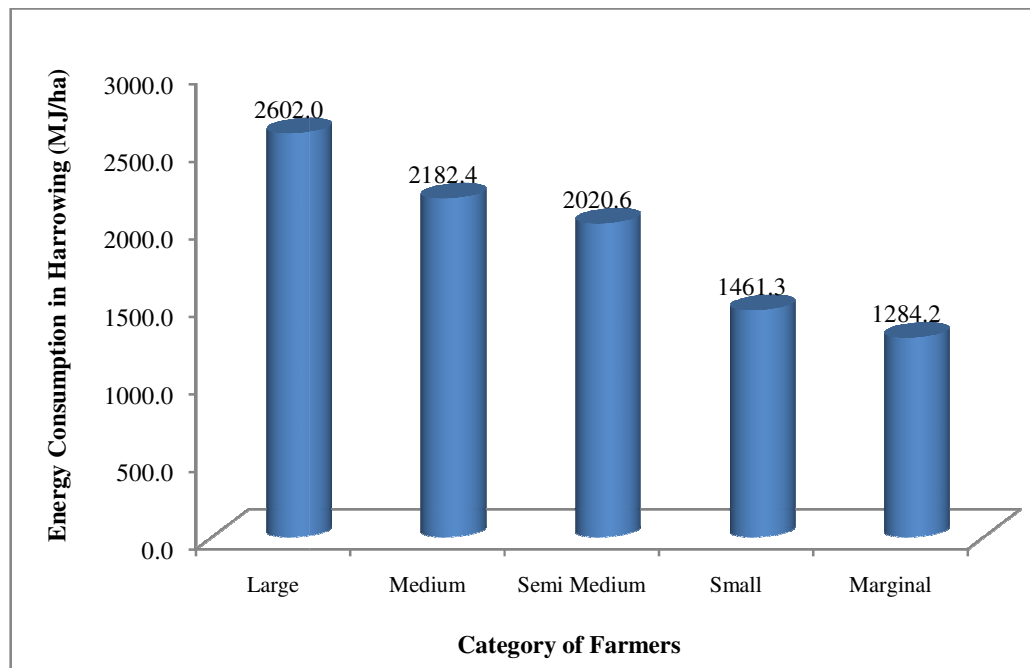


Fig 4.7 Total Energy Consumption in Harrowing Operation

4.4.1.2 Energy consumption in planking operation

Energy consumption pattern in planking operation for different categories of farmer was analyzed and presented in Fig 4.8. It has been found that energy requirement for planking in the case of large, medium, semi-medium, small and marginal category farmers is 545.0, 361.9, 370.3, 300.9 and 260.0 MJ/ha, respectively.

Large farmers use high horse power tractors and perform more planking operations (4-5) than other farmers; therefore, large farmers use more energy in planking. Small category farmers and marginal category farmers generally hire tractor from farmers of large and medium category and they perform the lesser number of planking operations (2-3) and therefore the energy consumption for this category of farmers has been found lesser than other category of farmers.

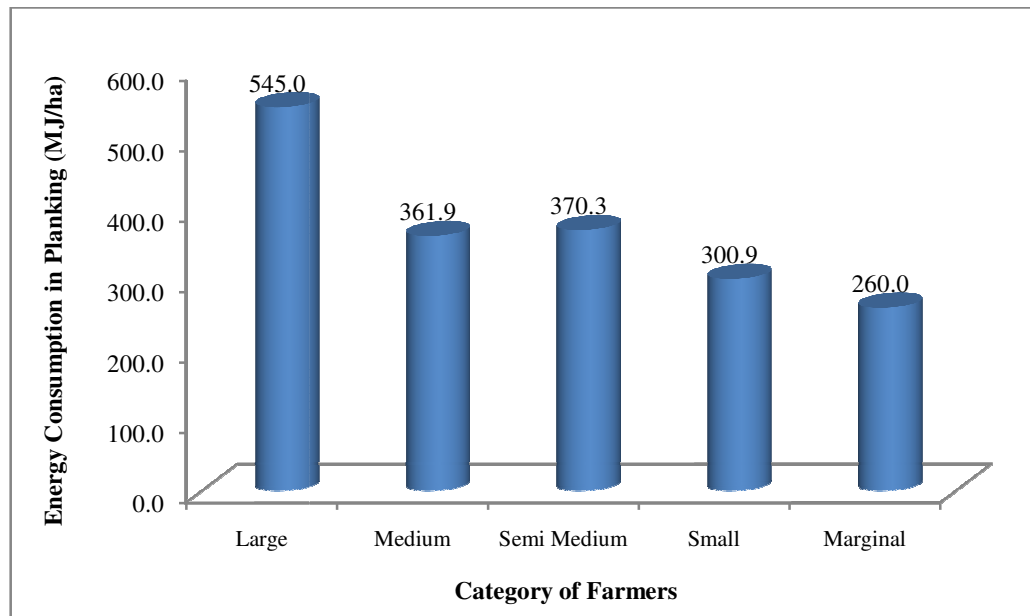


Fig 4.8 Total Energy Consumption in Planking Operation

4.4.1.3 Energy consumption in sowing operation

Energy consumption for sowing operation for different categories of farmer was calculated. Fig 4.9 shows the energy consumption pattern for sowing operation for different categories of farmer. It has been observed that the energy investment in sowing operation was 2945.5, 2804.0, 2857.0, 2895.2 and 2643.3 MJ/ha for large, medium, semi-medium, small categories of farmer respectively. Large and medium categories of farmer use seed cum ferti drill for sowing operation and normally the seed is applied at a rate of 100 kg/ha. Small and marginal category of farmers generally broadcast the seed manually. It has been observed that semi medium, small and marginal category of farmers generally adopt a high seed rate (110 kg/ha) as they broadcast the seed manually. Hence, there is not much a difference in energy requirement in sowing operation among all categories of farms.

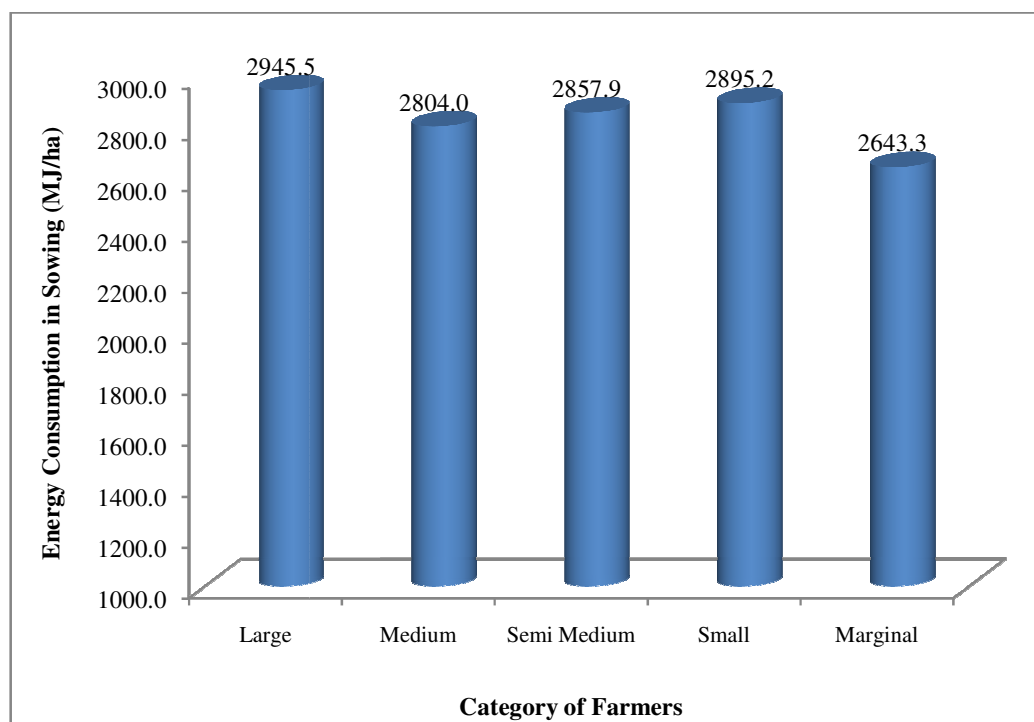


Fig 4.9 Total Energy Consumption in Sowing Operation

4.4.1.4 Energy consumption in irrigation operation

In Tarai region of Uttarakhand, wheat is cultivated under irrigated field conditions. The energy consumption pattern for irrigation operation for different category of farmers was analyzed and presented in Fig 4.10. The energy consumption pattern for irrigation operation has been found as 4192.7, 3504.5, 2565.9, 2652.8, 2779.2 MJ/ha for large, medium, semi-medium, small and marginal categories, respectively. Diesel engines or electric motors operated tube wells, artisan wells and canals are the main sources of irrigation in the region. It has been observed that 24.5% of the large, 31.9% of medium, 46.9% of semi medium, 42.9% of small and 36.6% of marginal farmers use canal water or artisan wells in which no fuel energy is required. Since the large number of semi medium farmers use canal water therefore the energy consumption is comparatively low.

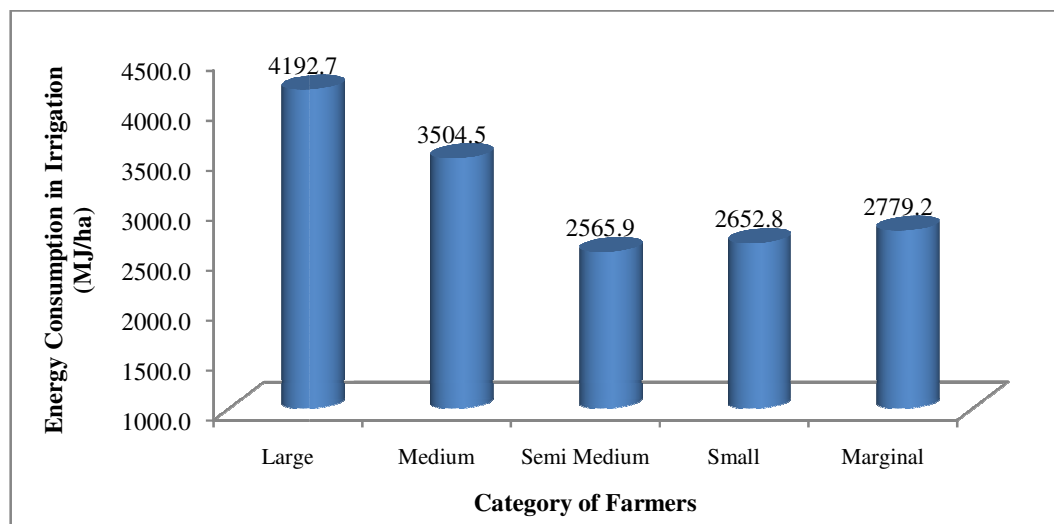


Fig 4.10 Total Energy Consumption in Irrigation Operation

4.4.1.5 Energy consumption in fertilizer application

Farmers in Tarai region generally apply fertilizer in wheat crop manually. The average energy consumption patterns for different categories of farmer were analyzed and discussed in Fig 4.11. It has been found that energy consumptions in fertilizer application were 11349.4, 11362.7, 10954.2, 9949.0 and 10129.1 MJ/ha for large, medium, semi-medium, small and marginal categories of farmer. It has also been observed that large and medium categories of farmer generally apply more fertilizer and therefore the energy consumption of these farmers is greater than other categories of farmer. Normally farmers in the region apply average 158 kg/ha N, 40 kg/ha P and 20 kg/ha K in wheat crop cultivation.

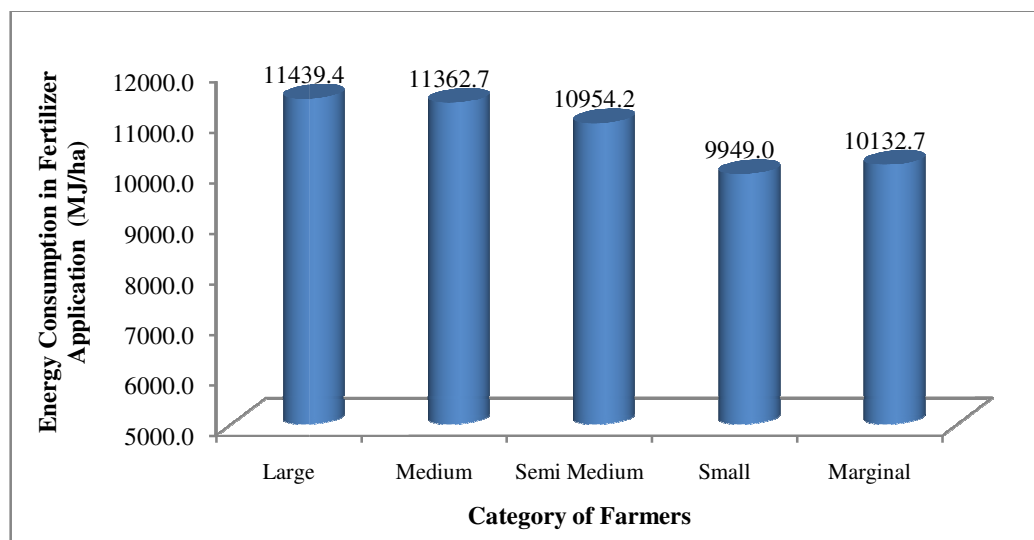


Fig 4.11 Total Energy Consumption in Fertilizer Application

4.4.1.6 Energy consumption in plant protection

In Tarai region of Uttarakhand, weed control in the wheat crop is commonly done by application of weedicides using either manually or power operated sprayer. The energy consumption in spraying operation was calculated for different categories and presented in Fig 4.12. It has been found that the average energy consumptions in spraying operation was 1170.8, 1061.5, 504.9, 518.1 and 495.6 MJ/ha for large, medium, semi-medium, small and marginal categories of farmer, respectively. Large and medium farmers in the region generally use tractor pto operated power sprayers, therefore, the energy consumption in spraying for large and medium farmer category is higher than other farmer's categories. It was also found that farmers of all categories use the same dose of weedicides for plant protection.

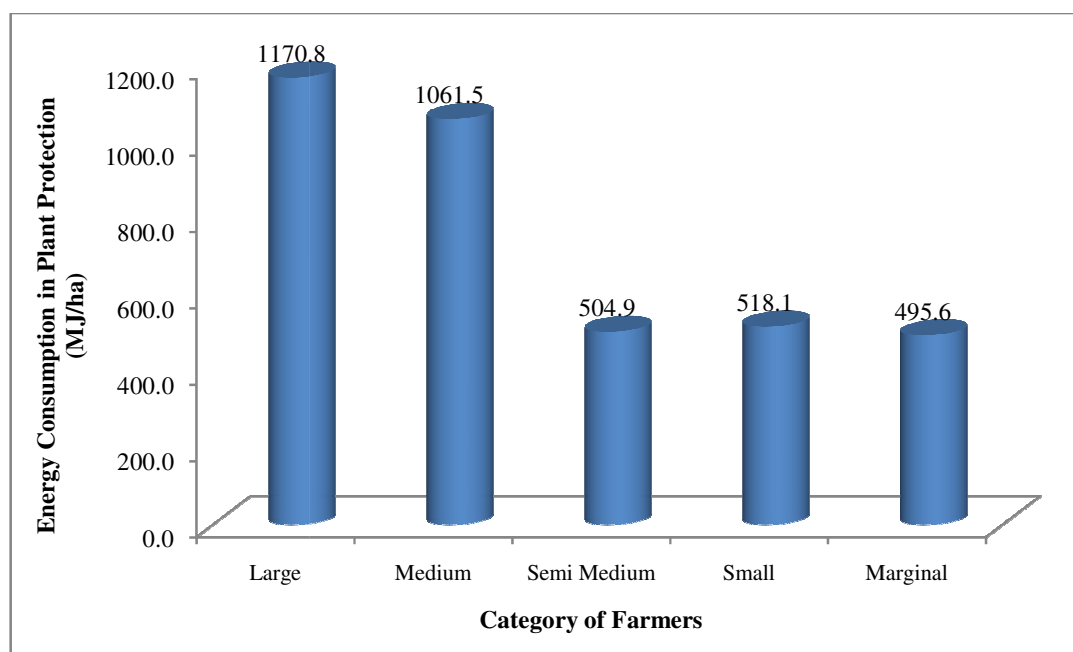


Fig 4.12 Total Energy Consumption in Plant Protection Operation

4.4.1.7 Energy consumption in harvesting and threshing

Farmers in Tarai region generally harvest their fields by combine harvesters. The energy consumption pattern for threshing and harvesting operation for different farmer categories was observed and presented in Fig 4.13. It has been found that large, medium, semi-medium, small and marginal categories of farmer incur energy investment of 2217.8, 2170.6, 2166.6, 2545.5 and 2503.3 MJ/ha respectively. It has been also observed that all farmers in large category harvest their fields by combine harvesters. However, 33.3% farmers in small category and 17.1% farmers in marginal

category manually harvest their field and thresh by power wheat thresher which requires higher energy input and therefore the energy consumption for harvesting and threshing operation is higher than other categories of farmer.

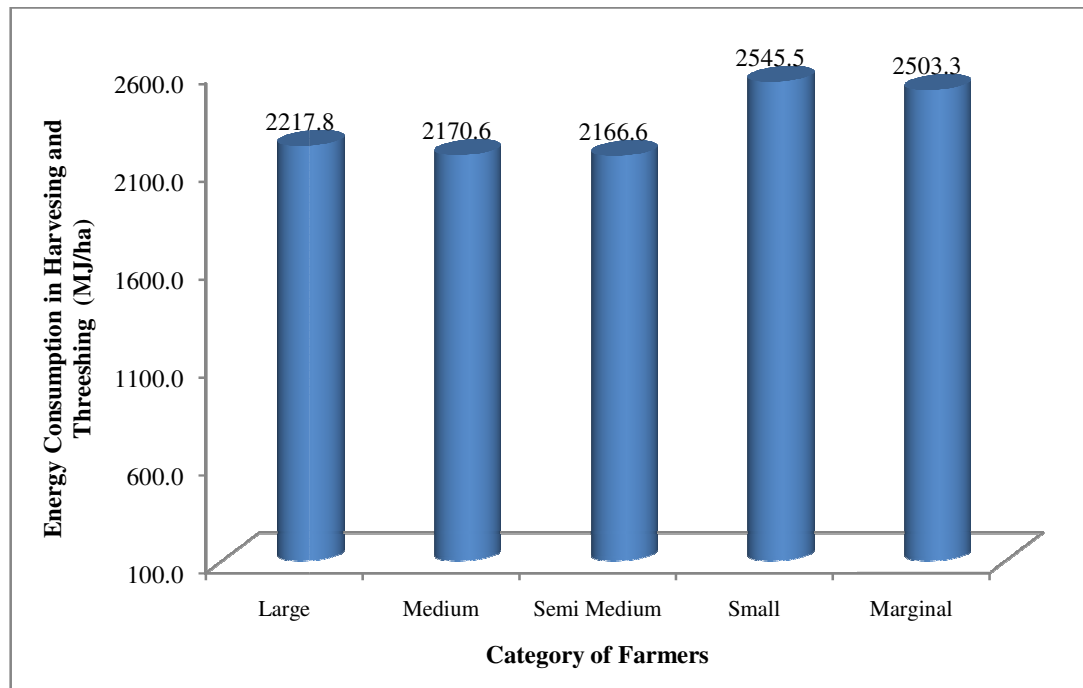


Fig 4.13 Total Energy Consumption in Harvesting and Threshing Operation

4.4.2 Source wise energy consumption pattern

The total energy consumption which is sum of the energy consumption of all sources for wheat crop production was analyzed and presented in Table E1 to E7.

4.4.2.1 Source wise energy consumption pattern for large farmers

The source wise energy consumption pattern of large farmers indicating total energy is presented in Fig 4.14. The average total energy consumption for wheat crop production for large category farmers has been found 24882.5 MJ/ha. Fertilizers share maximum energy (11437 MJ/ha) followed by diesel (5970.6 MJ/ha), electricity (4114.8 MJ/ha) and seeds (2435.0 MJ/ha). Human energy, agro-chemical and machinery share are 141.0, 491.2 and 293.2 MJ/ha, respectively. The percent wise energy consumption pattern was analyzed and results indicate that fertilizers incur 46.0% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 23.9%, 16.5%, 9.8%, 0.6%, 2.0% and 1.2%, respectively.

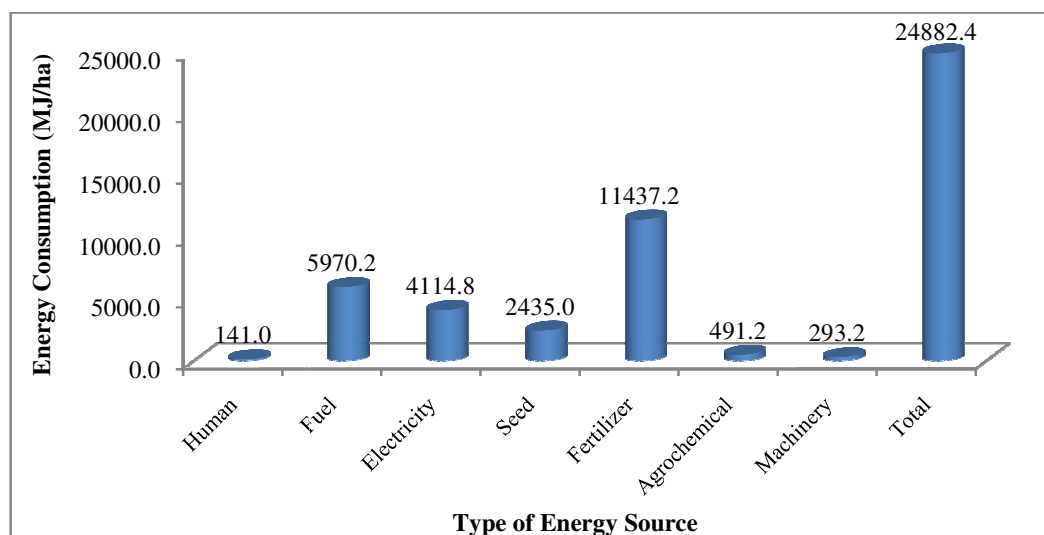


Fig 4.14 Source Wise Energy Consumption Pattern for Large Farmers

4.4.2.2 Source wise energy consumption pattern for medium farmers

The source wise energy consumption pattern of medium farmers is presented in Fig 4.15. It has been found that medium farmers use 23322.5 MJ/ha energy for wheat crop production. Fertilizers share maximum energy (11359.8 MJ/ha) followed by diesel (5171.1 MJ/ha), electricity (3420.4 MJ/ha) and seeds (2440.1 MJ/ha). Human energy, agro-chemical and machinery share 168.5 MJ/ha, 482.1 MJ/ha, 280.6MJ/ha, respectively. The percent wise energy consumption pattern was analyzed and results indicate that fertilizers incurred 48.7% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 22.2%, 14.7%, 10.5%, 0.7%, 2.1% and 1.2%, respectively.

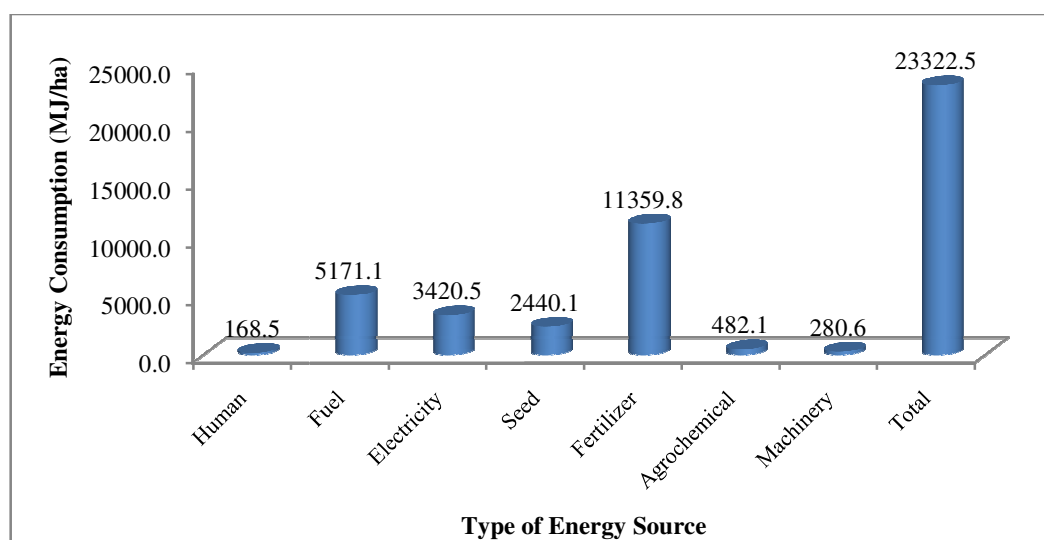


Fig 4.15 Source Wise Energy Consumption Pattern for Medium Farmers

4.4.2.3 Source wise energy consumption pattern for semi medium farmers

Source wise energy consumption pattern of semi medium farmers is presented in Fig 4.16. It has been found that semi medium farmers use 21361.1 MJ/ha energy for wheat crop production in which fertilizers incur maximum energy (10952.0 MJ/ha) followed by diesel (4711.7 MJ/ha), seed (2519.5 MJ/ha) and electricity (2202.2 MJ/ha). Human energy, agro-chemical and machinery share 207.1 MJ/ha, 482.5 MJ/ha, 286.2 MJ/ha, respectively. The percent wise energy consumption pattern was analyzed and results indicate that fertilizers incur 51.3% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 22.1%, 10.3%, 11.8%, 1%, 2.3% and 1.3%, respectively.

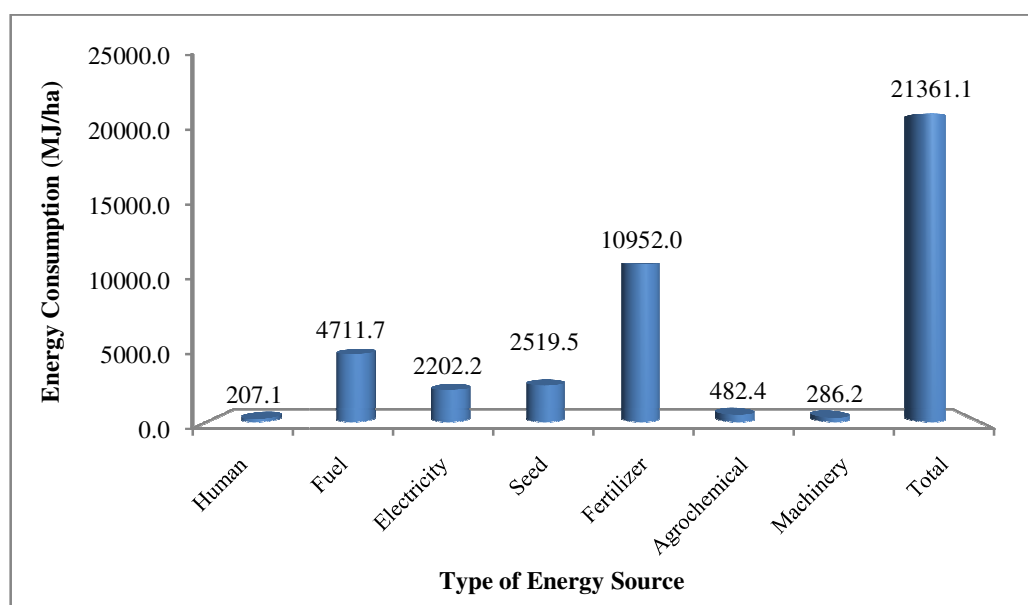


Fig 4.16 Source Wise Energy Consumption Pattern for Semi Medium Farmers

4.4.2.4 Source wise energy consumption pattern for small farmers

Source wise energy consumption pattern of small farmers is presented in Fig 4.17. It has been found that small farmers consume on average 20206.8 MJ/ha energy for wheat crop production. Fertilizers share maximum energy (9989.6 MJ/ha) followed by diesel (5009.9 MJ/ha), seed (2504.6 MJ/ha) and electricity (1693.4 MJ/ha). Human energy, agro-chemical and machinery share 318.1 MJ/ha, 483.0 MJ/ha, 298.3 MJ/ha, respectively. The percent wise energy consumption pattern was analyzed and results indicate that fertilizers incur 49.0% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 24.8%, 8.4%, 12.4%, 1.6%, 2.4% and 1.5%, respectively.

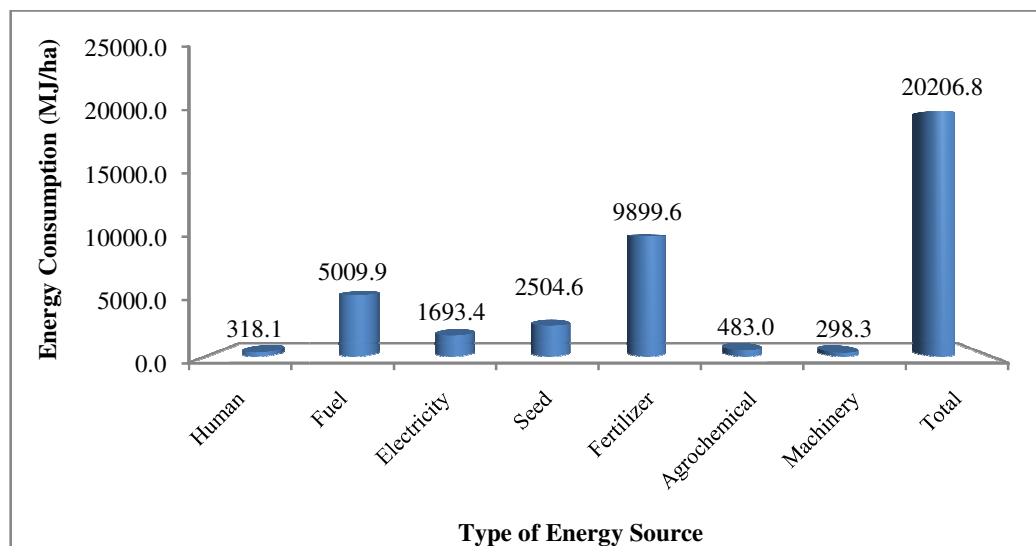


Fig 4.17 Source Wise Energy Consumption Pattern for Small Farmers

4.4.2.5 Source wise energy consumption pattern for marginal farmers

Source wise energy consumption pattern of marginal farmers is presented in Fig 4.18. It has been found that marginal farmers incur 20030.1MJ/ha energy for wheat crop production. Fertilizers share maximum energy (10130.3 MJ/ha) followed by diesel (4421.9 MJ/ha), seeds (2577.5 MJ/ha) and electricity (1914.1 MJ/ha). Human energy, agro-chemical and machinery share 233.2 MJ/ha, 482.6 MJ/ha, 270.5 MJ/ha, respectively. The percent wise energy consumption pattern was analyzed and results indicate that fertilizers incur 50.6% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 22.1%, 9.6%, 12.9%, 1.2%, 2.4% and 1.4%, respectively.

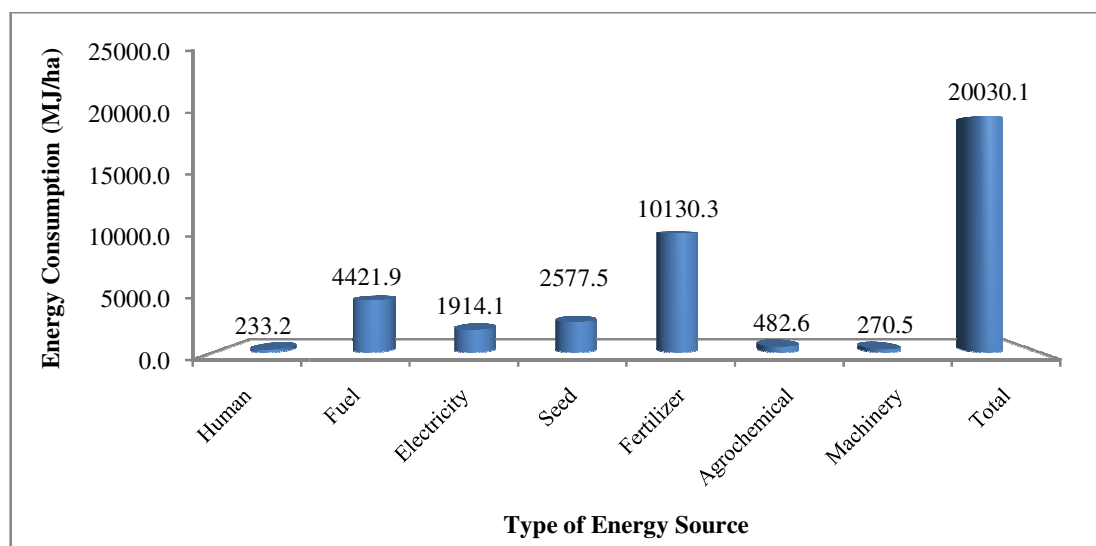


Fig 4.18 Source Wise Energy Consumption Pattern for Marginal Farmers

De (2005) has reported (Table 4.4) that the average energy consumption in wheat crop production in high yielding zone of Uttar Pradesh (which also include Uttarakhand) during the year 1986-87 and 2001-01 was 18926 and 17702 MJ/ha and the average wheat yield during the above period was 3.184 t/ha and 3.784 t/ha respectively. The present study indicates that the total energy consumption in the Tarai region of Uttarkhand is 20497 MJ/ha. This shows that there is a 7.7% and 13.6% increase in total energy consumption in the region as compared to the year 1986 and 2001 respectively. This increase in energy consumption at present level has also helped in increasing the crop yield by 24.5% and 10.3% which is now 4.220 t/ha. The comparison also shows that there is marginal decrease in energy productivity between 2001 and 2016 because of higher energy consumption.

Table 4.4 Increase in Energy Consumption and Crop Yield in Wheat Crop Production in Tarai Region of Uttarakhand

Particulars	1986-87	2000-01	2016
Total Energy Consumption (MJ/ha)	18926	17702	20497
Crop Yield (t/ha)	3.184	3.784	4.220
Energy Productivity (kg/MJ)	0.168	0.214	0.210

4.5 Energy Productivity and Energy Ratio

Output to input energy ratio and crop productivity per unit energy was calculated and presented in Table 4.5. It has been observed that energy productivity decreased with the decrease in energy input. The energy ratio for large, medium, semi-medium, small and marginal category has been found as 3.26, 3.15, 3.14, 3.11 and 2.95, respectively.

Table 4.5 Energy Productivity and Energy Ratio

Category of Farmers	Total Energy Input (MJ/ha)	Average Yield (t/ha)	Energy Productivity (kg/MJ)	Energy Ratio
Large	24882.44	5.52	0.222	3.26
Medium	23322.52	5.00	0.214	3.15
Semi Medium	21361.10	4.57	0.214	3.14
Small	20206.82	4.27	0.211	3.11
Marginal	20030.11	4.02	0.201	2.95
Weighted Average	20497.13	4.22	0.210	3.02

It is evident from the table that high energy input use by large, medium and semi medium farmers resulted in high yield of crop as well as high energy ratio. An attempt was also made to analyze the effect of total energy use in wheat crop production on its productivity in the other regions of the country where wheat is a major crop. The information available from the past research (De, 2005 and Srivastava, 2002) and the finding of present study is shown in Table 4.6. It is evident from the table that with an increase in total energy input, there is increase in wheat yield as well as energy productivity.

Table 4.6 Effect of Energy Input on Crop Yield and Productivity

Particulars	Tarai Region of Uttarakhand		Punjab	Madhya Pradesh
	Year			
	2001	2016	2005	2005
Total Energy Consumption (MJ/ha)	18926	20497	19368	13732
Crop Yield (t/ha)	3.184	4.220	4.677	2.751
Energy Productivity (kg/MJ)	0.168	0.210	0.241	0.200

4.6 Diesel and Electricity Use for Wheat Crop Production in Tarai Region of Uttarakhand

Average use of diesel and electricity for each unit operation was calculated and presented in Table E1-E7. An estimate was made on unit area wise consumption of diesel fuel and electricity for wheat crop production in the Tarai region of Uttarakhand. The consumption for fuel and electricity for wheat crop in Tarai region is presented in Table 4.7.

Table 4.7 Diesel Fuel and Electricity use in Wheat Crop Production in Tarai Region of Uttarakhand

Farmer Category	Use of Diesel (l/ha)	Use of Electricity	
		(MJ/ha)	(kWh/ha)
Large	106.02	4114.75	344.90
Medium	91.83	3420.45	286.71
Semi Medium	83.67	2345.82	196.32
Small	88.97	1693.39	141.94
Marginal	78.53	1914.15	160.44
Weighted Average	82.13	2050.08	171.84

The above consumption of diesel and electricity has been calculated based on available prime mover with the farmer. In order to estimate the consumption of diesel and electricity for high yield wheat crop zone of Udham Singh Nagar, the results of present study is used for the total area under wheat cultivation in Udham Singh Nagar and presented in Table 4.8.

Table 4.8 Total Estimated Diesel Fuel and Electricity Use in Wheat Cultivation in Tarai Region of Uttarakhand in 2016

Energy Source	Per Hectare Consumption	Total Area Under Wheat Cultivation (ha)	Total Consumption
Diesel Fuel	82.13 litre	95515	7.84 million litre
Electricity	171.84 kWh	95515	16.4 million kWh

De (2005) had reported the diesel and electricity consumption in high yielding wheat zone of Uttarakhand i.e. Tarai region is 95.9 l/ha (5402 MJ/ha) and 121.4 kWh respectively. The findings of present study is 82.1 l/ha (4623 MJ/ha). The decrease in diesel fuel consumption may be due to the fact that after formation of Uttarakhand state, the supply of electricity in agriculture has been more regular that encouraged the farmers to go for electric motor pump sets than the diesel engine pump sets. Also the decrease in diesel consumption may be due to the availability of more fuel efficient tractors over the last ten year interval.



*Summary
and
Conclusions*



SUMMARY AND CONCLUSIONS

Energy use patterns in a crop production system in the country have shown rapid changes with adoption of future technologies and production resources for achieving higher crop productivity. Generally, the trend has been towards higher uses of energy sources and fertilizers application which tend to increase energy investments. The agro-climatic conditions increase or decrease the level of energy requirements depending upon the type of soil, crop rotation and level of mechanization in the region. Thus the same crop being grown under different agro-climatic conditions would require different energy for crop production.

The major crop rotations being followed in Tarai region of Uttarakhand are the paddy- wheat, sugarcane-ratoon-wheat and paddy-paddy-pea. Wheat is a common crop in all crop rotations in Tarai region of Uttarakhand. The total area under wheat cultivation in the region is 95515 ha. In view of this the study was undertaken to assess the energy requirements for different unit operations in wheat crop production in Tarai region of Uttarakhand. The results are summarized as below:

1. The average farm power availability in Tarai region of Uttarakhand was found 2.05 kW/ha. The average farm power availability of large, medium, semi medium, small and marginal farmers was found 3.13, 4.11, 2.7, 2.1 and 1.65 kW/ha respectively.
2. The average mechanization index for harrowing operation in wheat crop production for large, medium, semi medium, small and marginal farmers was found 97%, 97%, 97%, 96% and 96 % respectively.
3. The average mechanization index for planking operation in wheat crop production for large, medium, semi medium, small and marginal farmers was found 96%, 94%, 94%, 93% and 92 % respectively.
4. The average mechanization index for sowing operation for large, medium, semi medium, small and marginal farmers was found 96%, 73%, 65%, 63% and 16 % respectively.

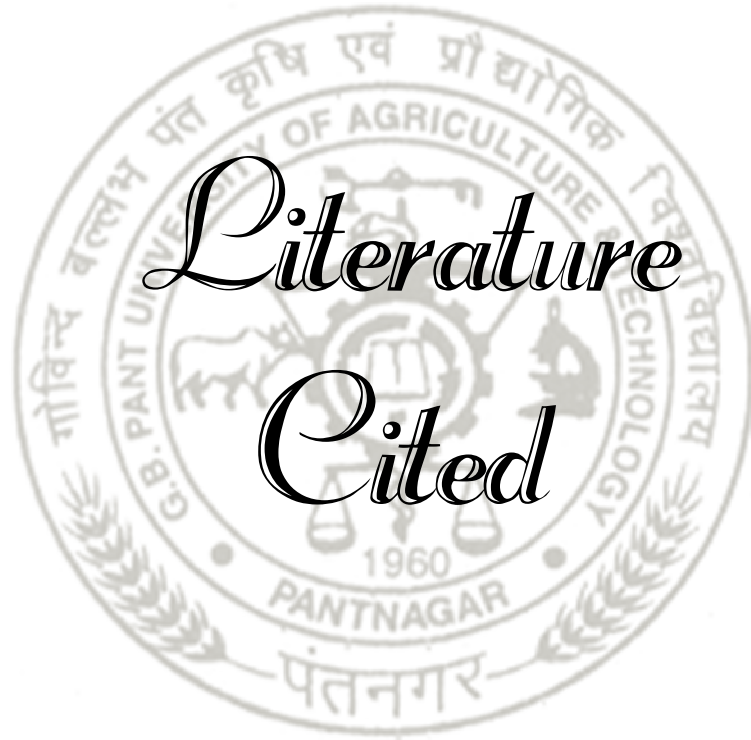
5. The average mechanization index for irrigation operation in wheat crop production for large, medium, semi medium, small and marginal farmers was observed 71%, 62%, 49%, 52% and 57 % respectively.
6. The average mechanization index for plant protection operation in wheat crop production for large, medium, semi medium, small and marginal farmers was observed 56%, 31%, 6%, 10% and 0 % respectively.
7. The average mechanization index for harvesting and the threshing operation was found 90%, 90%, 88%, 87% and 89% for large, medium, semi medium, small and marginal categories, respectively.
8. It was observed that 84.5% of large, 83.3% of medium, 73.5% of semi medium, 40.5% of small and 12.5% of marginal farmers have more than required implements for seed bed preparation while 17.8% of large, 16.6% of medium, 26.5% of semi medium, 52.4% of small and 87.5% of marginal farmers do not have sufficient number of implements for seed bed preparation.
9. For sowing operation, 82.2% of large, 41.8% of medium, 14.3% of semi medium, 14.6% of small and 0% of the marginal farmers own more than sufficient implements while 17.8% of large, 59.2% of medium, 83.7% of semi medium, 85.4% of small and 100% of marginal farmers do not own sufficient implements.
10. In plant protection operation, 75.6% of large, 62.5% of medium, 38.8% of semi medium, 52.4% of small and 7.3% of marginal farmers own more than sufficient implements while 22.2% of large, 37.5% of medium, 55.1% of semi medium, 40.5% of small and 92.7% of marginal farmers do not own sufficient implements.
11. In harvesting and threshing operation, 11.1% of large, 6.3% of medium, 12.2% of semi medium, 11.9% of small and 0% of marginal farmers own more than sufficient equipments while 88.9% of large, 93.7% of medium, 12.2% of semi medium, 88.1% of small and 100% of marginal farmers do not own sufficient implements.

12. The total energy consumption for tillage operation (harrowing by a trailed type disc harrow) has been found to be 2602.3, 2182.4, 2020.6, 1461.3, 1284.2 MJ/ha for large, medium, semi-medium, small and marginal categories of the farmer, respectively. The large and medium category farmers have high horse power tractors and they generally perform more (5-6 or even more) operations than other category of farmers and therefore energy consumption of large and medium category farmers was found to be greater than farmers of other categories. Farmers of small and marginal category generally hire tractors and implements from other category of farmers and perform lesser number of operations (2-3) to reduce their cost of cultivation therefore the energy consumption of small and marginal category farmer was found lesser than farmers of other categories.
13. It has been found that energy requirement for planking in the case of large, medium, semi-medium, small and marginal category farmers is 545.0, 361.9, 370.3, 300.9 and 260.1 MJ/ha, respectively.
14. The energy investment in sowing operation was observed as 2945.5, 2804.0, 2857.0, 2895.2 and 2643.3 MJ/ha for large, medium, semi-medium, small categories of farmer respectively.
15. The energy consumption pattern for irrigation operation has been found as 4192.7, 3504.5, 2565.9, 2652.8, 2779.2 MJ/ha for large, medium, semi-medium, small and marginal categories, respectively.
16. It has been found that energy consumptions in fertilizer application were 11349.4, 11362.7, 10954.2, 9901.5 and 10129.1 MJ/ha for large, medium, semi-medium, small and marginal categories of farmers. It has also been observed that large and medium categories of farmers generally apply more fertilizer and therefore the energy consumption of these farmers is greater than other categories of farmers.
17. The average energy consumptions in spraying operation was observed to be 1170.8, 1061.5, 504.9, 518.1 and 495.6 MJ/ha for large, medium, semi-medium, small and marginal categories of farmers, respectively.

18. It has been found that large, medium, semi-medium, small and marginal categories of farmers incur energy investment of 2217.8, 2170.6, 2166.6, 2545.5 and 2503.3 MJ/ha respectively in harvesting and threshing operation.
19. The average total energy consumption for wheat crop production for large category farmers has been found 24882.5 MJ/ha. Fertilizers share maximum energy (11437 MJ/ha) followed by diesel (5970.6 MJ/ha), electricity (4114.7 MJ/ha) and seeds (2435.0 MJ/ha). Human energy, agro-chemical and machinery share are 140.9, 491.1 and 293.2 MJ/ha, respectively. Fertilizers incur 46.0% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 23.9%, 16.5%, 9.8%, 0.6%, 2.0% and 1.2%, respectively.
20. The medium farmers use 23322.0 MJ/ha energy for wheat crop production. Fertilizers share maximum energy (11359.8 MJ/ha) followed by diesel (5171.6 MJ/ha), electricity (3420.4 MJ/ha) and seeds (2440.1 MJ/ha). Human energy, agro-chemical and machinery share 168.5 MJ/ha, 482.1 MJ/ha, 280.6MJ/ha, respectively. It was found that fertilizers incur 48.7% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 22.2%, 14.7%, 10.5%, 0.7%, 2.1% and 1.2%, respectively.
21. It has been found that semi medium farmers use 21361.1 MJ/ha energy for wheat crop production in which fertilizers incurred maximum energy (10952.0 MJ/ha) followed by diesel (4711.7 MJ/ha), seed (2519.5 MJ/ha) and electricity (2202.2 MJ/ha). Human energy, agro-chemical and machinery share 207.1 MJ/ha, 482.5 MJ/ha, 286.1 MJ/ha, respectively. Study also revealed that fertilizers incur 51.3% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 22.1%, 10.3%, 11.8%, 1%, 2.3% and 1.3%, respectively.
22. The small farmers consume on average 20206.8 MJ/ha energy for wheat crop production. Fertilizers share maximum energy (9989.6 MJ/ha) followed by diesel (5009.9 MJ/ha), seed (2504.6) MJ/ha and electricity (1693.4 MJ/ha). Human energy, agro-chemical and machinery share 318.2 MJ/ha, 483.0 MJ/ha, 298.30 MJ/ha, respectively. The percent wise energy consumption was found observed and fertilizers incur 49.0% of total energy. Diesel, electricity,

seeds, human energy, agrochemicals and machinery share 24.8%, 8.4%, 12.4%, 1.6%, 2.4% and 1.5%, respectively.

23. The marginal farmers incur 20030.1MJ/ha energy for wheat crop production. Fertilizers share maximum energy (10130.3 MJ/ha) followed by diesel (4421.9 MJ/ha), seeds (2577.5 MJ/ha) and electricity (1914.2 MJ/ha). Human energy, agro-chemical and machinery share 233.2 MJ/ha, 482.7 MJ/ha, 270.49 MJ/ha, respectively. Study indicates that fertilizers incur 50.6% of total energy. Diesel, electricity, seeds, human energy, agrochemicals and machinery share 22.1%, 9.6%, 12.9%, 1.2%, 2.4% and 1.4%, respectively.
24. The total energy consumption in wheat production in the Tarai region of Uttarkhand is 20497 MJ/ha, which shows 7.7% and 13.6% increase in total energy consumption in the region as compared to the year 1986 and 2001 respectively. The crop yield has also increased by 24.5% and 10.3% which is now 4.220 t/ha during the period.
25. The energy ratio for large, medium, semi-medium, small and marginal category has been found as 3.26, 3.15, 3.14, 3.11 and 2.95, respectively.
26. The average fuel and electricity use for wheat crop production was found to be 82.1 l/ha and 171.8 kWh/ha respectively which was 95.9 l/ha and 121.4 kWh/ha respectively in 2001.
27. The study thus indicate that higher energy input had resulted in higher crop yield of wheat crop in the region.



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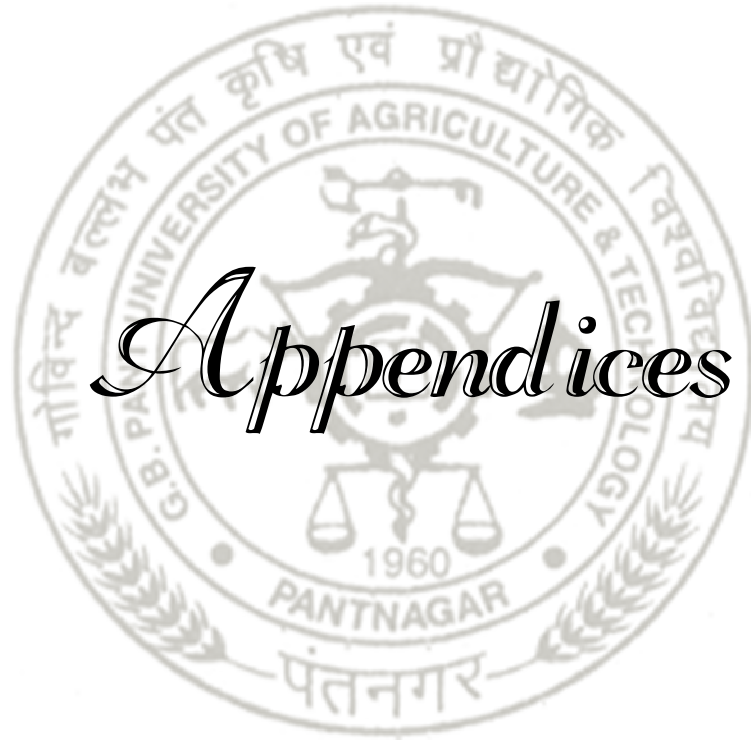
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Appendices



APPENDIX A

PERFORMA FOR COLLECTION OF INFORMATION ON ENERGY USE IN PRODUCTION AGRICULTURE IN UDHAM SINGH NAGAR

NAME

FATHER NAME

VILLAGE

TEHSIL

BLOCK

DISTRICT

PHONE NO./ MOBILE

1. Family details:

Paeticulars	Name	Age	Education	Occupation	Annual income
Male					
Female					
Children					

2. Land Holding:

Type	Irrigated	Rain-fed	Total
Owned			
Leased in			
Leased out			
Total			

Remark:

	Marginal (<1 ha)	Small (1-2 ha)	Semi- medium (2-4 ha)	Medium (4-10 ha)	Large (>10 ha)
Tick (√)					

3. Crops grown in a year:

Item discription	Crops / Cropping pattern	Area under crop (Acre/ha)
Cereals		
Oil seeds		
Sugarcane		
Maize		
Pulses		
Vegetables		
Any Other		

4. Irrigation system:

Type of source	Canal	Own pump/ Bore/ Boring/ tubewell	Pond	River	Water tank	Govt. tubewell	well	Sprinkler	Any other
Method									
Specification									
Other information									

A. Do you own machinery/ implements (Yes / No)

5. Mechanical power sources:

Mechanical power source	Make	Model	kW/hp	Nos.	Year of purchased
Tractor					
Power Tiller					
Combine Harvester					
Thresher					
Generator					
Reaper / Binder					
Diesel Engine					
Electric Motor					
Any other self propelled Machine					

6. Machinery own and their details:

Machinery/ Implements	Type	Make	Model	Specification	Nos.	Year of purchased
Ploughs	MB					
	Disc					
	Other					
Harrows	Disc Harrow					
	Drag Harrow					
	Any Other					
Cultivator						
Seed drills	Plain					
	Combination					
	Pneumatic seed- drill					
	Strip till drill					
	Zero till seed- drill					
	Roto till-drill					
Interculture Equipment						
Plant Protection	Sprayer					
	Duster					
	Any other					
Harvesting Equipment	Reaper					
	Forage harvester					
Threshing Equipment						
Winnowing Equipment						
Ridger						
Bund former						
Leveller						
Planker						
Puddler						
Rotavator						
Subsoiler						
Planter						
High crop sprayer						
Orchard sprayer						
Duster						
Canopy sprayer						
Electrostatic sprayer						
Post hole digger						
Hand implement	Spade					
	Khurpa					
	Gandasa					
	Saw					

F. Does rate of hiring increase as distance of travel increases from your home location:

Distance	10–20 km	20–30 km	30–40 km	40–50 km	Block	Tehsil
Tick (√)						

G. Satisfaction with Custom Hiring (Yes/ No)

1. If yes, why? If no, why?

.....

2. Any suggestion to provide better facility of custom hiring.

.....

8. Animals availability:

Drought Animals		Milch Animals	
Bullocks	He-Buffero	Cow	Buffalo
Numbers			

12. Details of manures, Fertilizer and Agro-chemical used:

Name	Crops in which used	Quantity used/ha or Acre	Mode of Procurement	Cost
Urea				
DAP				
NPK				
FYM				
Vermi-compost				
Any other				
Agrochemicals				
1.				
2.				
3.				

13. Details of Seed Used:

Crops	Variety used	Quantity used/ha or Acre	Mode of Procurement	Cost
Wheat				
Paddy				
Sugarcane				
Maize				
Oilseeds				
1.				
2.				
3.				
Pulses				
1.				
2.				
3.				

14. Requirement of Fuel:

Type of fuel	Use		Quantity	Cost
	Agricultural	Domestic		
Fire wood				
Agricultural residue				
Dung Cake				
Kerosene				
Petrol				
Diesel				
L.P.G.				
Biogas				
Engine Oil				

16. Use of Renewable Energy Technologies

Particulars	Type of Device in Use	Capacity of Device	Type of Feedstock used	Hours of Use in a Day	How Long in Use	Savings Over Conventional Fuels
Solar Energy						
Biogas						
Biomass Briquette						
Smokeless Chulha						
Producer Gas						
Any Other						

17. Biomass Availability and Use

Particulars	Area under cultivation	Quantity Available	Mode of Use	Surplus Available	Method of Disposal of Surplus Biomass
Cattle Manure					
Manure from Other Animals					
Agricultural residues					
Paddy					
Wheat					
Sugarcane					
Oilseed					
Pulses					
Millets					
Soybean					
Vegetables					
Orchards					
Flowers					
Any Other					

18. Poly House/ Glass House Crop Cultivation

Particulars	
Size of Poly/ Glass House	
Name(s) of Crop being cultivated	
Method of cultivation	
-Pot	
-Soil Bed	
-Any Other	
Tools/ Machines used for soil preparation	
Method of irrigation	
Plant protection Methods adopted	
Device for -water supply -hot air exhaust -humidity control -temperature Control -ventilation	
-rating of pump	
-rating of fan	
-Rating of any other power source	
-yearly use of electricity, kWh	
-annual income	

19. General Observations and Comments

Signature of Farmer

Signature of

Scientist with Date
Name of Scientist
Designation

APPENDIX B

Table B 1 Farm Power Availability of Large Farmer

Farmer No	Land Holding (ha)	Human Power (kW)	Power Availability				Farm Power Availability (kW/ha)
			Tractor Power (kW)	Electric Motors (kW)	Diesel Engine (kW)	Combine Harvester (kW)	
1	12	0.45	44.8	3.7	2.2	0.0	4.26
2	24	0.30	0.0	0.0	5 * 3.7	0.0	0.79**
3	40	0.60	38.8	0.0	4.9 * 3	0.0	1.36
4	10	0.30	35.8	3.7	4.9 * 3	0.0	5.48
5	20	0.52	35.8	3 * 3.7	4 * 3.7	0.0	3.12
6	17.8	0.45	29.8, 26.1	5.6	6 * 3.7	0.0	4.70
7	14	0.37	37.3	0.0	5 * .37	2*75.35	14.74**
8	11.2	0.37	0.0	0.0	0.0	0.0	0.03**
9	16	0.60	33.6	0.0	3.7	0.0	2.37
10	10	0.22	33.6	0.0	0.0	0.0	3.38
11	16	0.45	33.5, 37.3	6.0	3 * 3.7	0.0	5.53
12	15.2	0.30	26.1	0.0	3.7	0.0	1.98
13	22.8	0.60	37.3, 37.3	2 * 3.7	3 * 3.7	0.0	4.12
14	10	0.30	29.8,26.11	4 * 3.7	7.5	0.0	7.86**
15	12	0.52	38.8	3.3.7	0.0	0.0	4.21
16	12	0.45	33.6	5 * 3.7	3.7	0.0	4.70
17	20	0.37	33.6	5.6	5.6	0.0	2.26
18	66	0.37	33.6, 41.0	7 * 3.7, 1 * 5	3 * 3.7	0.0	1.79
19	28	0.60	26.1	6.0	7.5	0.0	1.43
20	10	0.22	0.0	0.0	0.0	0.0	0.02**
21	52.8	0.45	41.0, 26.1	6 * 3.7	0.0	0.0	1.70
22	30.4	0.30	35.8	3.7	0.0	0.0	1.31
23	12.8	0.60	44.8	5 * 3.7, 1 * 6	4 * 3.7, 1 * 5	0.0	7.01**
24	32	0.30	33.5,41.1,44.7	18 * 3.7	9 * 3.7 + 1 * 22.38	0.0	7.82**
25	20	0.52	37.3,33.5	7 * 3.7	4 * 3.7	0.0	5.62
26	10	0.45	31.3	0.0	0.0	0.0	3.18
27	72	0.37	41.2,41.2	7 * 3.7	4 * 3.7	0.0	1.71
28	12	0.37	33.6	0.0	7.5	0.0	3.45
29	11	0.60	33.6	0.0	7.5	0.0	3.78
30	20	0.22	37.3,29.84	0.0	4 * 3.7	75.3	7.87**
31	16.8	0.45	33.6	0.0	0.0	0.0	2.02
32	32	0.37	33.6	0.0	3 * 5 + 1 * 22.8	0.0	2.23
33	18	0.37	35.8	6.0	3.7	0.0	2.55
34	16	0.60	26.1,41.03	0.0	3.7	0.0	4.47
35	30.8	0.22	44.8	3 * 3.7	4 * 5 + 22.8	0.0	3.28
36	20	0.45	38.8	3 * 3.7	4 * 3.7 + 22.8	0.0	4.39
37	11.6	0.30	44.8	3.7	0.0	0.0	4.21
38	24.8	0.30	33.5,22.8	4 * 3.7	4 * 3.7	0.0	3.47
39	28	0.60	37.3,33.5	3 * 3.7	4 * 3.7	75.3	6.17
40	32	0.22	41.0	0.0	0.0	0.0	1.29
41	18.8	0.45	33.6	0.0	0.0	0.0	1.81
42	16	0.30	42.5	0.0	0.0	0.0	2.68
43	22	0.60	41.0	0.0	0.0	0.0	1.89
44	24	0.30	35.1	0.0	0.0	0.0	1.47
45	12	0.52	31.3	0.0	0.0	0.0	2.65

Average Farm Power Available = 3.13 kW/ha

* Points lies in outliers in the observation by Z score

Average tractor size 36.5 kW

Table B 2 Farm Power Availability of Medium Farmers

Farmer No	Land Holding (ha)	Human Power (kW)	Power Availability				Farm Power Availability (kW/ha)
			Tractor Power (kW)	Electric Motors (kW)	Diesel Engine (kW)	Combine Harvester (kW)	
1	7.27	0.37	26.9	6.0	3.7	0	5.09
2	8.08	0.60	26.1	2*3.7	0.0	0	4.22
3	6.4	0.22	38.8	6.3	3*3.7	0	7.08**
4	4.8	0.45	22.4	0.0	3.7	0	5.53
5	7.2	0.37	0.0	0.0	3.7	0	0.57**
6	4.4	0.37	0.0	0.0	6.0	0	1.45
7	5.6	0.60	37.3	6.0	0.0	0	7.84**
8	9.2	0.22	31.33, 26.1	0.0	7.5	0	7.08**
9	4.8	0.45	37.3	3.7	7.5	0	10.20**
10	6	0.30	31.3	0.0	5*3.7	0	8.35**
11	8	0.30	24.6	4*3.7	0.0	0	4.96
12	4.8	0.60	0.0	2*3.7	0.0	0	1.67
13	6	0.22	22.4	0.0	3.7	0	4.39
14	6	0.45	35.1	0.0	3.7	0	6.54
15	6	0.30	26.1	0.0	3.7	0	5.02
16	6	0.60	35.1	0.0	3.7	0	6.57
17	4.6	0.30	29.8	7.5	0.0	0	8.17**
18	5.6	0.52	31.3	5.2	0.0	0	6.61
19	4	0.45	22.4	0.0	4.5	0	6.84
20	4.8	0.37	37.3	7.5	0.0	0	9.41**
21	7.2	0.37	0.0	0.0	0.0	0	0.05*
22	8	0.60	37.3	10*3.7	3*3.7+1*5.6	0	11.45**
23	6	0.22	33.6	3*3.7	3.7	0	8.10**
24	8	0.45	44.8	0.0	3.7	0	6.12
25	4.8	0.37	29.8	0.0	3.7	0	7.06
26	8	0.37	22.4	0.0	0.0	0	2.85
27	6	0.60	26.1, 26.1	0.0	3.7	0	9.42**
28	6	0.22	29.8	0.0	3.7	0	5.62
29	6	0.45	0.0	0.0	3.7	0	0.69**
30	6	0.30	0.0	0.0	3*3.7	0	1.90
31	6	0.30	37.3	0.0	5.6	0	7.20**
32	6	0.60	0.0	3.7	3.7	0	1.33
33	7.6	0.22	37.3	0.0	3.7	0	5.42
34	6	0.45	22.4	0.0	3.7	0	4.43
35	6.8	0.30	26.1	9.0	0.0	0	5.21
36	8	0.60	0.0	0.0	0.0	0	0.08**
37	4	0.30	30.6	0.0	3.7	0	8.65**
38	6	0.52	33.5, 41.1	0.0	3*3.7	0	14.37**
39	9.2	0.45	41.0	3*3.7, 1*4.5	7.5	0	7.02
40	10	0.37	33.6	0.0	0.0	0	3.40
41	7.2	0.37	35.1	0.0	0.0	0	4.93
42	4	0.60	0.0	0.0	0.0	0	0.20**
43	6	0.22	33.6	2*4.5	0.0	0	7.14**
44	7.6	0.45	0.0	0.0	0.0	0	0.06**
45	4	0.37	0.0	0.0	0.0	0	0.09**
46	8	0.37	22.4	0.0	0.0	0	2.85
47	4.8	0.37	26.1	0.0	0.0	0	5.51

Average Farm Power Available = 4.11 kW/ha

* **Points lies in outliers in the observation by Z score

Average tractor size 31.7 kW

Table B 3 Farm Power Availability of Semi Medium Farmers

Farmer No	Land Holding (ha)	Human Power (kW)	Power Availability				Farm Power Availability (kW/ha)
			Tractor Power (kW)	Electric Motors (kW)	Diesel Engine (kW)	Combine Harvester (kW)	
1	4	0.45	38.8	0.0	3.7	0	10.74**
2	2.4	0.30	0.0	0.0	3.7	0	1.68
3	2.8	0.30	37.3	2.8	0.0	0	14.76**
4	4	0.60	44.8	0.0	0.0	0	11.34**
5	4	0.22	0.0	4.5	0.0	0	1.55
6	2.8	0.45	35.8	4.2	3.7	0	15.76**
7	2.8	0.30	0.0	0.0	0.0	0	0.11
8	2.8	0.60	0.0	0.0	3.7	0	1.55
9	3.4	0.30	0.0	2.8	3.7	0	2.28
10	3.2	0.52	33.6	3.1	0.0	0	11.94**
11	2.8	0.45	26.1	2.8	0.0	0	10.82**
12	4	0.37	33.6	3*3.7	0.0	0	12.22**
13	3.23	0.37	33.6	5.6	0.0	0	12.82**
14	2.02	0.60	0.0	4.5	0.0	0	3.25
15	4	0.22	29.1	0.0	3.7	0	8.26
16	2	0.45	0.0	4.5	0.0	0	3.21
17	2.4	0.37	22.4	4.5	0.0	0	11.97**
18	3.2	0.37	35.1	2.8	0.0	0	12.24**
19	2.4	0.60	44.8	0.0	3.7	0	20.45**
20	2.57	0.22	33.6	5.6	0.0	0	16.05**
21	2.8	0.45	0.0	0.0	0.0	0	0.16
22	3.2	0.30	33.6	0.0	3.7	0	11.75**
23	2.8	0.30	22.4	5.6	3.7	0	12.10**
24	2.8	0.60	89.5	7*3.7, 1*5.8	3*3.7	0	51.37**
25	4	0.22	29.8	4.5	0.0	0	9.01**
26	4	0.45	29.8	5.6	0.0	0	9.44**
27	4.8	0.30	26.1	2*4	3.7	0	8.53**
28	2.8	0.60	35.8	2*4	0.0	0	16.86**
29	3.2	0.30	0.0	0.0	3.7	0	1.26
30	4	0.52	22.4	0.0	3.7	0	6.66
31	2.8	0.45	33.6	0.0	3.7	0	13.48**
32	2.4	0.37	0.0	0.0	0.0	0	0.16
33	4	0.37	22.4	0.0	3.7	0	6.62
34	4	0.60	33.6	3*3.7	3.7	0	13.20**
35	2.4	0.22	0.0	0.0	0.0	0	0.09
36	2.8	0.45	0.0	0.0	0.0	0	0.16
37	4	0.37	30.6	5.6	3.7	0	10.54**
38	2.8	0.37	0.0	0.0	0.0	0	0.13
39	3.6	0.60	35.8	3.4	0.0	0	11.36**
40	3.2	0.22	26.1	0.0	0.0	0	8.23**
41	2.4	0.45	31.3	3.9	3.7	0	16.97**
42	4	0.30	31.3	0.0	0.0	0	7.91
43	3	0.30	0.0	0.0	0.0	0	0.10
44	2.8	0.37	37.3	0.0	0.0	0	13.45**
45	4	0.37	0.0	0.0	0.0	0	0.09
46	2.8	0.30	44.0	0.0	0.0	0	15.83**
47	2.8	0.22	0.0	0.0	0.0	0	0.08
48	2.8	0.30	0.0	0.0	0.0	0	0.11
49	3.2	0.30	0.0	0.0	3.7	0	1.26

Average Farm Power Available = 2.70 kW/ha

* **Points lies in outliers in the observation by Z score

Average tractor size 30.6 kW

Table B 4 Farm Power Availability of Small Farmers

Farmer No	Land Holding (ha)	Human Power (kW)	Power Availability				Farm Power Availability (kW/ha)
			Tractor Power (kW)	Electric Motors (kW)	Diesel Engine (kW)	Combine Harvester (kW)	
1	1.6	0.30	0.0	4.8	0.0	0	3.22
2	1.2	0.22	0.0	0.0	0.0	0	0.19
3	1.2	0.30	0.0	0.0	0.0	0	0.25
4	2	0.37	0.0	5.2	3.7	0	4.66
5	1.4	0.22	44.8	6.0	0.0	0	36.39**
6	2	0.30	0.0	0.0	0.0	0	0.15
7	2	0.30	0.0	3.7	3.7	0	3.88
8	1.6	0.37	38.8	3.7	0.0	0	26.81**
9	1.21	0.37	0.0	7.5	0.0	0	6.47
10	1.61	0.30	0.0	6.0	0.0	0	3.89
11	2	0.22	26.1	6.0	0.0	0	16.15**
12	1.21	0.30	0.0	0.0	0.0	0	0.25
13	1.6	0.15	29.8	6.0	0.0	0	22.47**
14	1.7	0.30	26.1	3.7	0.0	0	17.73**
15	1.2	0.22	0.0	6.0	0.0	0	5.16
16	1.6	0.30	33.6	6.0	0.0	0	24.90**
17	1.2	0.37	29.1	6.0	0.0	0	29.53**
18	1.2	0.22	18.7	3.7	0.0	0	18.84**
19	1.6	0.30	35.8	4.5	0.0	0	25.36**
20	1.6	0.30	0.0	4.8	0.0	0	3.22
21	2	0.37	26.1	3.7	0.0	0	15.11**
22	1.2	0.37	0.0	0.0	0.0	0	0.31
23	1.3	0.30	29.8	0.0	3.7	0	26.05**
24	1.2	0.22	0.0	0.0	3.7	0	3.29
25	1.6	0.30	0.0	0.0	3.7	0	2.52
26	2	0.15	26.1	4.5	0.0	0	15.37**
27	1.4	0.30	0.0	6.0	0.0	0	4.48
28	1.2	0.22	26.1	0.0	3.7	0	25.05**
29	1.2	0.30	0.0	0.0	0.0	0	0.25
30	1.8	0.37	0.0	0.0	0.0	0	0.21
31	2	0.22	0.0	0.0	0.0	0	0.11
32	1.6	0.30	0.0	0.0	0.0	0	0.19
33	2	0.30	33.6	0.0	3.7	0	18.80**
34	2	0.37	29.8	0.0	7.5	0	18.84**
35	1.2	0.37	0.0	0.0	3.7	0	3.42
36	1.8	0.30	33.6	0.0	0.0	0	18.82**
37	1.6	0.22	0.0	0.0	0.0	0	0.14
38	1.6	0.30	0.0	5.2	0.0	0	3.45
39	2	0.15	0.0	0.0	0.0	0	0.07
40	1.6	0.30	0.0	0.0	3.7	0	2.52
41	1.6	0.22	0.0	0.0	0.0	0	0.14

Average Farm Power Available = 2.10 kW/ha

* **Points lies in outliers in the observation by Z score

Average tractor size 30.5 kW

Table B 5 Farm Power Availability of Marginal Farmers

Farmer No	Land Holding	Human Power	Power Availability				Farm Power Availability
			Tractor Power	Electric Motors	Diesel Engine	Combine Harvester	
	(ha)	(kW)	(kW)	(kW)	(kW)	(kW)	(kW/ha)
1	0.4	0.37	0.0	0.0	0.0	0	0.93
2	0.8	0.22	0.0	0.0	0.0	0	0.28
3	0.2	0.30	0.0	0.0	0.0	0	1.49
4	0.8	0.30	26.1	3.7	0.0	0	37.67**
5	1	0.37	0.0	6.0	0.0	0	6.34
6	0.4	0.37	0.0	3.7	0.0	0	10.26**
7	0.5	0.30	26.1	3.7	0.0	0	60.28**
8	0.4	0.22	0.0	0.0	0.0	0	0.55
9	0.8	0.30	0.0	0.0	0.0	0	0.37
10	0.6	0.15	0.0	6.0	0.0	0	10.09**
11	0.2	0.30	0.0	0.0	0.0	0	1.49
12	0.4	0.22	0.0	0.0	0.0	0	0.55
13	0.8	0.30	0.0	0.0	0.0	0	0.37
14	0.4	0.37	0.0	0.0	0.0	0	0.93
15	0.8	0.22	0.0	3.7	0.0	0	4.94
16	0.6	0.30	18.7	0.0	0.0	0	31.58**
17	0.4	0.30	0.0	0.0	0.0	0	0.74
18	0.8	0.37	0.0	0.0	0.0	0	0.47
19	1	0.37	0.0	3.7	0.0	0	4.10
20	1	0.30	0.0	0.0	2.2	0	2.54
21	1	0.22	0.0	0.0	3.7	0	3.95
22	0.8	0.30	0.0	3.7	0.0	0	5.04
23	0.4	0.15	0.0	0.0	0.0	0	0.37
24	1	0.30	0.0	3.7	0.0	0	4.03
25	1	0.22	26.1	0.0	0.0	0	26.33**
26	0.4	0.30	0.0	0.0	3.7	0	10.07**
27	0.4	0.37	0.0	0.0	0.0	0	0.93
28	0.6	0.22	22.4	7.5	0.0	0	50.11**
29	0.8	0.30	0.0	0.0	0.0	0	0.37
30	0.8	0.30	0.0	0.0	0.0	0	0.37
31	0.4	0.37	0.0	7.5	0.0	0	19.58**
32	0.9	0.37	0.0	0.0	3.7	0	4.56
33	1	0.30	26.1	0.0	0.0	0	26.41**
34	0.4	0.22	0.0	3.7	0.0	0	9.88**
35	0.2	0.30	0.0	0.0	0.0	0	1.12
36	0.6	0.15	0.0	0.0	0.0	0	0.25
37	1	0.30	0.0	0.0	0.0	0	0.30
38	0.8	0.22	0.0	0.0	0.0	0	0.28
39	0.8	0.30	0.0	0.0	0.0	0	0.37
40	1	0.37	0.0	0.0	0.0	0	0.37

Average Farm Power Available = 1.65 kW/ha

** Points lies in outliers in the observation by Z score

Average tractor size 25.6 kW

APPENDIX C

Table C1 Mechanization Index in Harrowing Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	0.98	0.96	0.96	0.96	0.96
2	0.97	0.97	0.97	0.96	0.96
3	0.98	0.97	0.98	0.96	0.96
4	0.97	0.96	0.97	0.96	0.96
5	0.97	0.98	0.98	0.96	0.96
6	0.96	0.96	0.98	0.98	0.96
7	0.98	0.97	0.97	0.96	0.96
8	0.97	0.97	0.97	0.96	0.96
9	0.97	0.97	0.97	0.97	0.96
10	0.98	0.96	0.97	0.96	0.96
11	0.98	0.97	0.97	0.96	0.96
12	0.97	0.97	0.97	0.96	0.96
13	0.98	0.96	0.96	0.96	0.96
14	0.97	0.97	0.97	0.97	0.96
15	0.98	0.96	0.97	0.96	0.96
16	0.97	0.97	0.97	0.96	0.96
17	0.97	0.96	0.97	0.97	0.95
18	0.97	0.97	0.97	0.97	0.96
19	0.96	0.97	0.96	0.95	0.96
20	0.97	0.97	0.97	0.97	0.96
21	0.98	0.96	0.98	0.96	0.96
22	0.97	0.97	0.97	0.96	0.96
23	0.98	0.97	0.97	0.96	0.96
24	0.97	0.98	0.97	0.97	0.96
25	0.98	0.97	0.96	0.96	0.96
26	0.97	0.98	0.98	0.96	0.96
27	0.98	0.97	0.97	0.96	0.96
28	0.97	0.96	0.97	0.96	0.96
29	0.97	0.96	0.97	0.96	0.96
30	0.97	0.97	0.97	0.96	0.96
31	0.97	0.97	0.97	0.96	0.96
32	0.97	0.97	0.96	0.96	0.96
33	0.97	0.97	0.97	0.96	0.96
34	0.96	0.97	0.97	0.97	0.96
35	0.98	0.98	0.96	0.97	0.96
36	0.98	0.96	0.97	0.96	0.96
37	0.98	0.96	0.97	0.97	0.96
38	0.97	0.97	0.97	0.96	0.96
39	0.97	0.97	0.97	0.96	0.96
40	0.98	0.97	0.97	0.96	0.96
41	0.97	0.98	0.97	0.96	
42	0.98	0.97	0.96	0.96	
43	0.98	0.97	0.97		
44	0.97	0.97	0.97		
45	0.97		0.97		
46			0.97		
47			0.97		
48			0.98		
49			0.96		
Average	0.97	0.97	0.97	0.96	0.96

Table C2 Mechanization Index in Planking Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	0.97	0.95	0.90	0.93	0.93
2	0.91	0.92	0.90	0.93	0.93
3	0.96	0.95	0.90	0.93	0.93
4	0.96	0.94	0.93	0.93	0.93
5	0.96	0.96	0.93	0.93	0.94
6	0.95	0.93	0.93	0.93	0.93
7	0.96	0.94	0.95	0.93	0.93
8	0.96	0.92	0.95	0.91	0.95
9	0.96	0.89	0.92	0.89	0.93
10	0.96	0.94	0.93	0.93	0.93
11	0.96	0.89	0.93	0.93	0.93
12	0.95	0.95	0.94	0.95	0.95
13	0.96	0.89	0.97	0.95	0.95
14	0.93	0.89	0.97	0.95	0.95
15	0.96	0.94	0.97	0.95	0.95
16	0.96	0.89	0.97	0.93	0.95
17	0.96	0.94	0.97	0.96	0.93
18	0.96	0.89	0.96	0.93	0.9
19	0.94	0.95	0.95	0.93	0.93
20	0.94	0.95	0.97	0.93	0.9
21	0.97	0.93	0.94	0.95	0.9
22	0.96	0.92	0.94	0.95	0.9
23	0.97	0.92	0.94	0.91	0.87
24	0.96	0.97	0.95	0.95	0.87
25	0.96	0.96	0.95	0.93	0.87
26	0.95	0.9	0.93	0.93	0.87
27	0.97	0.95	0.95	0.95	0.87
28	0.96	0.94	0.95	0.95	0.93
29	0.96	0.94	0.95	0.95	0.94
30	0.96	0.89	0.95	0.91	0.88
31	0.96	0.92	0.88	0.91	0.94
32	0.96	0.87	0.88	0.91	0.94
33	0.96	0.87	0.90	0.91	0.86
34	0.95	0.87	0.94	0.91	0.95
35	0.92	0.96	0.97	0.89	0.88
36	0.96	0.93	0.97	0.89	0.88
37	0.97	0.95	0.97	0.96	0.88
38	0.96	0.89	0.95	0.91	0.94
39	0.96	0.95	0.92	0.95	0.91
40	0.97	0.96	0.96	0.95	0.88
41	0.96	0.97	0.94	0.93	
42	0.97	0.9	0.95	0.95	
43	0.97	0.89	0.91		
44	0.92	0.87	0.89		
45	0.95	0.88	0.95		
46		0.88	0.95		
47		0.95	0.91		
48		0.95	0.91		
49			0.93		
Average	0.96	0.94	0.94	0.93	0.92

Table C3 Mechanization Index in Sowing Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	0.96	0.96	0.93	0	0
2	0.95	0.95	0.95	0	0
3	0.95	0.95	0.95	0	0
4	0.95	0.93	0.93	0	0.93
5	0.95	0.95	0.95	0	0.93
6	0.96	0.93	0.96	0.96	0
7	0.95	0	0.95	0.96	0
8	0.95	0	0	0.96	0.93
9	0.94	0.95	0	0.96	0
10	0.96	0.95	0	0.96	0
11	0.96	0.95	0.93	0.96	0
12	0.93	0.95	0.93	0.93	0.93
13	0.95	0.91	0.95	0.93	0.93
14	0.95	0	0.95	0.93	0
15	0.96	0.93	0	0.93	0
16	0.95	0	0.93	0.93	0
17	0.95	0.93	0	0.95	0
18	0.96	0.95	0.92	0.93	0
19	0.93	0.93	0.95	0.93	0.93
20	0.95	0.95	0	0.95	0
21	0.96	0.93	0.95	0.95	0
22	0.95	0.95	0	0.93	0
23	0.96	0	0.95	0.93	0
24	0.96	0.95	0.93	0.93	0
25	0.95	0.95	0.96	0.93	0
26	0.94	0.96	0.94	0.93	0.93
27	0.96	0.94	0.94	0.93	0
28	0.94	0.92	0.94	0.93	0
29	0.94	0.93	0.95	0	0
30	0.95	0.93	0	0	0
31	0.94	0	0.93	0	0
32	0.94	0	0.95	0	0
33	0.95	0.95	0	0	0
34	0.95	0	0.93	0	0.93
35	0.95	0.95	0.95	0	0
36	0.96	0.93	0	0.95	0
37	0.96	0.93	0	0.95	0
38	0.95	0	0.94	0.95	0
39	0.95	0.95	0	0.95	0
40	0	0.96	0.95	0.95	0
41	0.95	0.96	0.93	0.95	
42	0.96	0.95	0.95	0.95	
43	0.95	0.95	0.95		
44	0.95	0	0.94		
45	0.95	0.94	0.95		
46		0	0		
47		0.95	0.94		
48		0.94	0		
49			0		
Average	0.93	0.73	0.65	0.63	0.16

Table C4 Mechanization Index in Irrigation Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	0.89	0.93	0.93	0.96	0.93
2	0.93	0	0	0.93	0
3	0.93	0.93	0.93	0	0
4	0.93	0	0	0	0
5	0.93	0.93	0.93	0.93	0
6	0.94	0.93	0.93	0.93	0.87
7	0.93	0.93	0.93	0	0.92
8	0	0.93	0	0	0.87
9	0.93	0	0.92	0.91	0.87
10	0.93	0.93	0	0.93	0.93
11	0.93	0.93	0	0.92	0.93
12	0.93	0.91	0	0.92	0.92
13	0.93	0	0.87	0	0.93
14	0.98	0	0	0.92	0.93
15	0	0.93	0.93	0.87	0.93
16	0.93	0.93	0.93	0	0.93
17	0.95	0.93	0.93	0	0.87
18	0.98	0.93	0	0	0
19	0.98	0	0.93	0	0
20	0	0	0.91	0	0.93
21	0	0.89	0.89	0.9	0.87
22	0.93	0	0	0.87	0.89
23	0.93	0.96	0	0	0
24	0.93	0.93	0.93	0.91	0
25	0.98	0.93	0	0.91	0
26	0.95	0.93	0.91	0.91	0
27	0.96	0.93	0.91	0.89	0
28	0.93	0	0.91	0.92	0.93
29	0.93	0.93	0.91	0.91	0.93
30	0.91	0.93	0.93	0	0.93
31	0.91	0.93	0.93	0	0
32	0.93	0.93	0.93	0	0
33	0.91	0.95	0	0	0.93
34	0.93	0.91	0.91	0.91	0.93
35	0.93	0.91	0	0	0.93
36	0.93	0.93	0	0.93	0.87
37	0	0	0	0	0
38	0.93	0	0.91	0	0.93
39	0.93	0.91	0	0.93	0
40	0	0.91	0	0.91	0.93
41	0	0.91	0	0.93	
42	0	0.91	0.93	0.93	
43	0	0	0		
44	0	0	0		
45	0	0.93	0		
46		0	0.93		
47		0	0		
48		0	0		
49			0.93		
Average	0.71	0.62	0.49	0.52	0.57

Table C5 Mechanization Index in Plant Protection Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	0.74	0.82	0.74	0.74	0.00
2	0.74	0.81	0.74	0.74	0.00
3	0.74	0.00	0.74	0.74	0.00
4	0.74	0.83	0.85	0.74	0.00
5	0.74	0.00	0.00	0.74	0.00
6	0.74	0.84	0.00	0.59	0.00
7	0.74	0.00	0.00	0.00	0.00
8	0.74	0.87	0.00	0.00	0.00
9	0.74	0.78	0.00	0.00	0.00
10	0.74	0.00	0.00	0.00	0.00
11	0.74	0.00	0.00	0.00	0.00
12	0.87	0.88	0.00	0.00	0.00
13	0.84	0.00	0.00	0.00	0.00
14	0.84	0.00	0.00	0.00	0.00
15	0.86	0.85	0.00	0.00	0.00
16	0.87	0.00	0.00	0.00	0.00
17	0.86	0.78	0.00	0.00	0.00
18	0.86	0.81	0.00	0.00	0.00
19	0.86	0.00	0.00	0.00	0.00
20	0.86	0.84	0.00	0.00	0.00
21	0.88	0.93	0.00	0.00	0.00
22	0.86	0.85	0.00	0.00	0.00
23	0.81	0.85	0.00	0.00	0.00
24	0.82	0.85	0.00	0.00	0.00
25	0.87	0.85	0.00	0.00	0.00
26	0.87	0.85	0.00	0.00	0.00
27	0.00	0.59	0.00	0.00	0.00
28	0.85	0.00	0.00	0.00	0.00
29	0.87	0.00	0.00	0.00	0.00
30	0.87	0.00	0.00	0.00	0.00
31	0.84	0.00	0.00	0.00	0.00
32	0.78	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00
39	0.00	0.00	0.00	0.00	0.00
40	0.00	0.00	0.00	0.00	0.00
41	0.00	0.00	0.00	0.00	
42	0.00	0.00	0.00	0.00	
43	0.00	0.00	0.00	0.10	
44	0.00	0.00	0.00		
45	0.00	0.00	0.00		
46		0.00	0.00		
47		0.00	0.00		
48		0.00	0.00		
49			0.00		
Average	0.56	0.31	0.06	0.10	0.00

Table C6 Mechanization Index in Harvesting and Threshing Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	0.89	0.9	0.91	0.92	0.92
2	0.89	0.8	0.91	0.92	0.92
3	0.89	0.9	0.91	0.92	0.92
4	0.89	0.73	0.8	0.92	0.92
5	0.89	0.9	0.79	0.92	0.74
6	0.89	0.69	0.91	0.81	0.92
7	0.9	0.9	0.91	0.92	0.92
8	0.9	0.9	0.91	0.92	0.92
9	0.78	0.9	0.91	0.79	0.92
10	0.9	0.9	0.91	0.92	0.92
11	0.9	0.9	0.91	0.73	0.77
12	0.9	0.9	0.91	0.92	0.92
13	0.9	0.9	0.91	0.7	0.92
14	0.9	0.9	0.91	0.75	0.92
15	0.9	0.9	0.91	0.71	0.92
16	0.9	0.91	0.91	0.75	0.77
17	0.9	0.91	0.7	0.92	0.68
18	0.9	0.91	0.73	0.73	0.92
19	0.9	0.91	0.91	0.66	0.92
20	0.9	0.91	0.91	0.79	0.92
21	0.9	0.91	0.3	0.92	0.92
22	0.9	0.91	0.91	0.74	0.72
23	0.9	0.91	0.91	0.92	0.72
24	0.9	0.91	0.91	0.76	0.92
25	0.9	0.91	0.91	0.92	0.92
26	0.9	0.91	0.92	0.92	0.92
27	0.9	0.91	0.92	0.92	0.92
28	0.9	0.91	0.92	0.92	0.92
29	0.9	0.91	0.92	0.92	0.92
30	0.9	0.91	0.92	0.92	0.92
31	0.9	0.91	0.92	0.92	0.92
32	0.9	0.91	0.92	0.92	0.92
33	0.9	0.91	0.92	0.92	0.92
34	0.9	0.91	0.92	0.92	0.92
35	0.9	0.91	0.92	0.92	0.92
36	0.9	0.91	0.92	0.92	0.92
37	0.9	0.91	0.92	0.92	0.93
38	0.9	0.91	0.92	0.77	0.93
39	0.9	0.91	0.92	0.92	0.75
40	0.9	0.91	0.92	0.92	0.93
41	0.9	0.91	0.92	0.92	
42	0.9	0.91	0.92	0.92	
43	0.9	0.91	0.92		
44	0.9	0.91	0.92		
45	0.9	0.91	0.92		
46		0.91	0.24		
47		0.91	0.92		
48		0.91	0.92		
49			0.92		
Average	0.90	0.90	0.88	0.87	0.89

APPENDIX D

Table D 1 Farm Machinery Demand Supply Gap in Seedbed Preparation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	0.36	0.81	0.93	-0.06	-0.02
2	-0.99	0.74	0.90	-0.06	-0.03
3	-0.48	0.73	0.91	0.96	-0.03
4	0.44	0.74	-0.13	-0.08	-0.01
5	0.44	0.76	0.87	-0.09	0.97
6	1.89	0.79	0.81	0.93	-0.04
7	0.66	-0.15	-0.13	-0.11	-0.01
8	-0.56	-0.04	0.89	-0.08	0.98
9	0.44	0.79	-0.15	0.94	-0.01
10	0.55	0.76	-0.12	-0.04	-0.03
11	1.25	0.79	0.82	-0.10	-0.02
12	0.00	0.61	0.89	0.94	-0.01
13	1.25	0.79	0.90	-0.05	-0.01
14	1.68	-0.21	1.00	0.94	-0.03
15	0.63	0.66	0.83	0.94	-0.01
16	0.83	0.76	-0.09	-0.04	-0.03
17	0.06	0.70	0.89	0.96	0.98
18	-2.37	0.79	-0.07	0.96	-0.02
19	0.29	0.74	0.90	0.96	-0.03
20	0.71	0.63	0.82	0.96	-0.03
21	1.11	0.74	1.97	-0.07	-0.03
22	-1.05	0.78	0.90	0.91	-0.04
23	1.07	0.66	-0.10	-0.04	-0.02
24	2.06	0.68	0.93	0.94	-0.01
25	0.82	0.70	1.00	-0.06	-0.02
26	0.16	0.85	-0.03	-0.08	0.99
27	-0.98	0.90	1.85	0.91	-0.02
28	0.44	0.72	0.81	-0.05	-0.02
29	0.31	1.68	1.00	0.96	0.97
30	1.25	0.72	0.91	0.00	-0.05
31	0.21	-0.32	-0.17	0.00	-0.03
32	-0.18	-0.39	0.83	-0.01	-0.02
33	0.17	0.81	0.94	0.00	-0.04
34	0.95	0.74	-0.13	0.94	0.94
35	0.17	1.00	0.91	0.94	-0.02
36	0.05	0.64	0.87	-0.09	-0.01
37	0.57	0.62	-0.10	0.95	-0.03
38	1.01	-0.41	-0.02	-0.09	-0.04
39	0.85	1.00	0.81	-0.07	-0.03
40	-0.18	1.83	-0.12	-0.07	-0.03
41	0.51	0.71	0.87	-0.07	-0.03
42	0.34	0.51	0.85	-0.06	
43	0.18	0.53	0.91		
44	0.59	-0.13	0.74		
45	0.57	0.85	1.00		
46		-0.17	0.88		
47		0.81	0.85		
48		0.79	0.89		
49			-0.15		
Adequacy of Equipment Availability (No. of Farmer)					
Positive	36	40	36	17	5
Zero	1	0	0	3	0
Negative	8	8	13	22	35

Positive value indicates that farmer having more than sufficient number of implement

Negative value indicates that farmer having less than sufficient number of implement

A zero value indicates that farmer adequate number of implement

Table D2 Farm Machinery Demand Supply Gap in Sowing Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	-0.13	-0.04	-0.05	-0.02	-0.01
2	0.74	-0.04	-0.02	-0.01	-0.01
3	0.57	-0.05	-0.03	-0.01	-0.01
4	-0.11	0.91	-0.03	-0.01	-0.01
5	0.89	0.93	-0.03	-0.01	-0.01
6	0.97	0.95	0.98	0.99	-0.01
7	0.92	-0.04	-0.04	-0.02	-0.01
8	-0.11	-0.01	-0.03	-0.02	-0.01
9	0.87	0.97	-0.03	-0.01	-0.01
10	0.94	-0.06	-0.03	-0.01	-0.01
11	0.79	0.97	0.97	-0.01	-0.01
12	0.84	-0.06	-0.03	-0.02	-0.01
13	-0.11	-0.03	-0.04	-0.02	-0.01
14	0.94	0.97	-0.03	-0.01	-0.01
15	-0.09	-0.04	-0.03	-0.02	-0.01
16	-0.03	0.96	0.98	-0.02	-0.01
17	0.82	-0.04	-0.02	0.99	-0.01
18	0.40	0.96	-0.02	0.98	-0.01
19	0.84	-0.04	-0.03	-0.01	-0.01
20	0.94	-0.06	-0.03	0.99	-0.01
21	0.74	-0.04	-0.01	-0.02	-0.01
22	0.85	0.95	-0.03	-0.02	-0.01
23	0.86	-0.07	-0.03	-0.02	-0.01
24	0.78	-0.06	-0.02	-0.01	-0.01
25	0.87	0.94	-0.03	-0.01	-0.01
26	0.89	-0.03	-0.01	-0.01	-0.01
27	0.45	0.98	-0.04	0.98	-0.01
28	-0.13	-0.06	-0.04	-0.02	-0.01
29	-0.10	-0.06	-0.03	-0.02	-0.01
30	0.83	0.97	-0.03	-0.01	-0.01
31	0.82	-0.06	0.97	-0.01	-0.01
32	0.81	-0.06	-0.02	-0.01	-0.01
33	0.84	0.96	-0.01	-0.02	-0.01
34	0.83	-0.04	0.97	-0.01	-0.01
35	0.78	-0.04	-0.02	-0.02	-0.01
36	0.79	-0.05	-0.04	0.98	-0.01
37	0.88	0.93	-0.03	-0.01	-0.01
38	0.74	-0.08	0.00	-0.02	-0.01
39	0.70	-0.04	-0.04	-0.02	-0.01
40	0.62	0.94	-0.03	-0.02	-0.01
41	0.87	0.90	0.96	-0.02	-0.01
42	0.83	0.90	-0.03	-0.02	
43	0.78	0.92	-0.03		
44	0.89	-0.03	0.96		
45	0.89	-0.04	-0.03		
46		-0.04	-0.03		
47		0.96	-0.04		
48		0.96	-0.02		
49			-0.03		
Adequacy of Equipment Availability (No. of Farmer)					
Positive	37	20	7	5	0
Zero	0	0	1	0	0
Negative	8	29	41	37	41

Positive value indicates that farmer having more than sufficient number of implement

Negative value indicates that farmer having less than sufficient number of implement

A zero value indicates that farmer adequate number of implement

Table D 3 Farm Machinery Demand Supply Gap in Plant Protection Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	1.44	-0.05	0.91	0.95	-0.01
2	0.54	0.89	0.95	1.00	-0.02
3	1.72	-0.05	0.94	0.97	0.98
4	1.70	-0.03	-0.04	0.96	-0.01
5	1.77	0.94	0.96	0.97	-0.02
6	3.76	-0.09	0.92	1.97	-0.03
7	0.65	-0.09	0.93	0.97	-0.01
8	0.81	-0.12	1.93	0.97	-0.01
9	0.88	-0.07	0.89	0.98	-0.01
10	1.44	-0.09	-0.07	1.97	-0.02
11	1.68	-0.06	-0.07	0.96	-0.02
12	-0.24	-0.09	0.92	-0.04	-0.01
13	-0.26	-0.12	0.92	0.94	-0.01
14	-0.27	-0.06	-0.07	-0.03	-0.02
15	0.70	-0.09	-0.07	0.97	0.99
16	0.39	-0.05	0.00	0.98	-0.02
17	-0.15	-0.06	0.91	0.96	-0.02
18	-0.15	0.91	-0.06	-0.04	-0.01
19	0.95	-0.04	-0.04	0.96	-0.02
20	0.57	-0.09	0.93	0.97	-0.03
21	0.56	-0.10	-0.08	-0.03	-0.03
22	0.00	1.80	-0.02	-0.04	-0.03
23	-0.23	0.83	-0.07	-0.04	-0.01
24	0.96	0.89	-0.07	-0.06	-0.01
25	-0.15	0.91	-0.06	-0.03	-0.01
26	0.89	0.91	0.00	0.96	-0.01
27	-0.15	0.93	1.98	-0.04	0.99
28	0.82	0.91	-0.11	0.94	-0.01
29	0.91	0.89	0.00	-0.04	-0.02
30	-0.21	0.90	0.93	0.97	-0.02
31	-0.15	0.91	0.91	0.00	-0.02
32	0.09	0.89	-0.06	0.00	-0.01
33	0.67	0.87	-0.03	0.00	-0.03
34	0.74	0.90	-0.07	0.94	-0.03
35	3.44	0.97	-0.04	-0.06	-0.01
36	0.59	0.89	-0.09	0.97	-0.01
37	1.56	0.87	-0.07	-0.05	-0.02
38	4.44	0.82	-0.01	-0.04	-0.03
39	3.47	0.84	-0.11	-0.04	-0.02
40	1.74	1.91	-0.08	-0.04	-0.02
41	5.33	0.83	-0.10	-0.04	-0.03
42	2.56	0.83	1.91	-0.04	
43	0.67	3.91	0.93		
44	0.56	0.89	-0.11		
45	0.83	0.81	2.00		
46		0.76	-0.08		
47		0.89	-0.11		
48		0.87	0.94		
49			-0.07		
			-0.04		
Adequacy of Equipment Availability (No. of Farmer)					
Positive	34	30	19	22	3
Zero	1	0	3	3	0
Negative	10	18	27	17	38

Positive value indicates that farmer having more than sufficient number of implement

Negative value indicates that farmer having less than sufficient number of implement

A zero value indicates that farmer adequate number of implement

Table D 4 Farm Machinery Demand Supply Gap in Harvesting and Threshing Operation

Farmer No	Large	Medium	Semi Medium	Small	Marginal
1	-0.12	-0.05	-0.03	-0.01	0.00
2	-0.23	0.80	-0.03	-0.01	-0.01
3	-0.39	-0.07	-0.04	-0.01	-0.01
4	-0.10	0.81	0.93	-0.01	0.00
5	-0.19	-0.06	0.88	-0.02	-0.02
6	0.83	0.87	-0.04	0.94	-0.01
7	-0.14	-0.07	-0.04	-0.02	0.00
8	-0.11	-0.04	-0.03	-0.02	-0.01
9	0.47	-0.05	-0.03	-0.02	0.00
10	-0.10	-0.09	-0.03	-0.01	-0.01
11	-0.16	-0.05	-0.03	0.95	-0.02
12	-0.15	-0.06	-0.03	-0.02	0.00
13	-0.22	-0.08	-0.03	0.96	0.00
14	-0.10	-0.05	-0.04	-0.02	-0.01
15	0.88	-0.06	-0.03	0.93	0.00
16	-0.12	-0.06	-0.02	-0.03	-0.02
17	-0.19	-0.06	0.83	-0.02	-0.02
18	-0.64	-0.06	0.92	-0.02	0.00
19	-0.27	-0.04	-0.02	-0.02	-0.01
20	-0.10	-0.05	-0.03	-0.02	-0.01
21	-0.51	-0.04	0.90	-0.02	-0.01
22	-0.30	-0.05	-0.03	-0.06	-0.03
23	-0.12	-0.07	-0.03	-0.01	-0.03
24	0.69	-0.08	-0.03	0.96	0.00
25	-0.19	-0.06	-0.03	-0.01	-0.01
26	-0.10	-0.08	-0.03	-0.02	-0.01
27	-0.70	-0.05	-0.04	-0.02	0.00
28	-0.12	-0.08	-0.04	-0.02	0.00
29	-0.11	-0.06	-0.05	-0.01	-0.01
30	-0.19	-0.06	-0.03	-0.01	-0.01
31	-0.16	-0.06	-0.03	-0.02	-0.01
32	-0.31	-0.06	-0.04	-0.02	0.00
33	-0.18	-0.06	-0.03	-0.02	-0.01
34	-0.16	-0.06	-0.02	-0.02	-0.01
35	-0.30	-0.07	-0.04	-0.02	0.00
36	-0.19	-0.06	-0.04	-0.01	0.00
37	-0.11	-0.07	-0.02	-0.02	-0.01
38	-0.24	-0.08	-0.03	-0.02	-0.01
39	-0.27	-0.04	-0.04	-0.02	-0.03
40	-0.31	-0.06	-0.03	-0.02	-0.01
41	-0.18	-0.09	-0.04	-0.02	-0.01
42	0.84	-0.10	-0.03	-0.02	
43	-0.21	-0.07	-0.02		
44	-0.23	-0.03	-0.04		
45	-0.12	-0.06	-0.03		
46		-0.07	0.88		
47		-0.04	-0.04		
48		-0.05	-0.03		
49			-0.03		
			-0.03		
Adequacy of Equipment Availability (No. of Farmer)					
Positive	5	3	6	5	0
Zero	0	0	0	0	0
Negative	40	45	43	37	41

Positive value indicates that farmer having more than sufficient number of implement

Negative value indicates that farmer having less than sufficient number of implement

A zero value indicates that farmer adequate number of implement

APPENDIX E

Table E 1.1 Consumption of Direct and Indirect Energy Sources in Harrowing Operation by Large Farmers

Farmer Number	Area for wheat (ha)	Rated width of harrow	No. of Operation	Man hours (h/ha)	Fuel		Direct Energy (MJ/ha)			Indirect Energy (MJ/ha)			Total Energy (MJ/ha)
					RHP basis (l/ha)	Farmer Estimate (l/ha)	Human	Fuel	Total	Tractor	Machinery	Total	
Farmer preparing field by disc harrow													
1	12	1.616	5	6.45	52.84	38.69	12.64	2975.67	2988.31	90.37	80.86	171.2	3159.53
2	24	2.099	5	4.96	29.78	29.78	9.73	1676.85	1686.58	90.00	88.17	168.17	1864.75
3	40	2.339	5	4.45	31.27	26.73	8.73	1760.54	1769.27	70.69	60.51	163.78	1900.47
4	10	1.856	6	6.73	44.85	40.40	13.20	2525.29	2538.49	88.90	98.52	187.42	2725.91
5	10	1.856	6	6.73	44.85	40.40	13.20	2525.29	2538.49	88.90	91.48	187.42	2718.87
6	2.4	1.856	5	5.61	26.51	33.67	11.00	1492.83	1503.83	89.05	82.10	171.15	1674.98
7	7.2	1.856	5	5.61	39.68	33.67	11.00	2234.58	2245.58	74.46	82.10	156.56	2402.14
8	10	1.856	6	6.73	40.41	40.41	13.20	2275.46	2288.66	74.00	98.53	140.00	2461.19
9	12	1.856	5	5.61	32.05	33.67	11.00	1804.66	1815.65	74.08	82.10	156.18	1971.83
10	6	1.856	8	8.98	64.53	53.87	17.60	3633.78	3651.38	118.53	131.36	249.89	3901.27
11	16	1.856	5	5.61	40.33	33.67	11.00	2271.11	2282.11	74.08	82.10	156.18	2438.29
12	15.2	1.856	7	7.86	37.85	47.14	15.40	2131.60	2147.00	88.40	114.94	203.34	2350.34
13	10	1.856	8	8.98	62.29	53.87	17.60	3507.35	3524.95	117.61	131.36	248.97	3773.92
14	6	1.616	5	6.45	34.95	38.69	12.64	1968.16	1980.80	80.93	80.86	161.79	2142.58
15	8	1.856	5	5.61	39.39	33.67	11.00	2217.93	2228.92	89.05	82.10	171.15	2400.07
16	3.2	1.616	5	6.45	40.26	38.69	12.64	2266.90	2279.53	82.74	80.86	163.60	2443.13
17	20	1.856	5	5.61	35.04	33.67	11.00	1972.89	1983.89	72.01	82.10	154.11	2137.99
18	66	2.099	8	7.94	49.58	47.65	15.56	2791.82	2807.39	101.90	116.18	242.97	3025.46
19	15.2	1.856	5	5.61	25.14	33.67	11.00	1415.52	1426.52	66.60	82.10	148.69	1575.21
20	5.2	1.856	6	6.73	40.40	40.40	13.20	2275.15	2288.35	74.00	98.52	100.00	2460.87
21	24	2.339	5	4.45	32.94	26.73	8.73	1854.69	1863.42	62.43	74.48	136.91	2000.33
22	14	1.856	8	8.98	59.80	53.87	17.60	3367.06	3384.66	118.53	131.36	249.89	3634.55

23	12.8	1.429	6	8.75	64.93	52.49	17.15	3656.04	3673.18	122.62	71.31	193.93	3867.11
24	20	1.856	5	5.61	35.72	33.67	11.00	2011.12	2022.12	78.65	82.10	160.75	2182.87
25	14	1.856	9	10.10	71.43	60.61	19.80	4022.24	4042.04	134.04	147.78	281.81	4323.85
26	10	1.856	9	10.10	54.30	60.61	19.80	3057.52	3077.31	122.98	147.78	270.76	3348.07
27	60	2.099	6	5.96	44.21	35.73	11.67	2489.73	2501.41	94.51	105.80	200.32	2701.72
28	12	1.856	5	5.61	31.64	33.67	11.00	1781.72	1792.71	72.01	82.10	154.11	1946.82
29	9.2	1.616	7	9.03	50.90	54.16	17.69	2866.13	2883.82	115.83	113.20	229.03	3112.86
30	16	1.856	5	5.61	37.87	33.67	11.00	2132.62	2143.62	70.24	82.10	152.34	2295.96
31	16.8	1.856	5	5.61	31.64	33.67	11.00	1781.72	1792.71	72.01	82.10	154.11	1946.82
32	18	1.856	7	7.86	44.30	47.14	15.40	2494.40	2509.80	100.81	114.94	215.75	2725.55
33	14.8	1.856	6	6.73	44.85	40.40	13.20	2525.29	2538.49	88.90	98.52	187.42	2725.91
34	16	1.856	7	7.86	34.75	47.14	15.40	1956.74	1972.14	102.91	114.94	217.85	2189.99
35	20	2.099	5	4.96	40.04	29.78	9.73	2254.38	2264.10	72.65	88.17	160.82	2424.92
36	19.2	2.099	6	5.96	41.80	35.73	11.67	2353.93	2365.60	94.51	105.80	200.32	2565.92
37	9.2	1.856	5	5.61	45.99	33.67	11.00	2589.73	2600.73	78.65	82.10	160.75	2761.48
Average				6.69	42.68	40.14	13.11	2403.20	2416.31	89.42	96.53	184.58	2602.26
Farmers using rotavator for seed bed preparation													
38	9.2	2.030	2	4.93	30.86	38.00	9.66	1737.83	1747.49	63.21	87.51	160.75	1898.21
39	24	2.030	2	4.93	36.57	39.00	9.66	2059.29	2068.95	78.17	87.51	137.10	2234.63
40	28	2.030	2	4.93	30.76	45.00	9.66	1731.86	1741.52	65.03	72.07	150.72	1878.62
41	28.8	2.030	2	4.93	37.90	47.00	9.66	2134.18	2143.83	82.55	87.51	165.68	2313.89
42	12	2.030	2	4.93	36.57	54.00	9.66	2059.29	2068.95	78.17	87.51	137.10	2234.63
43	16	2.030	2	4.93	31.25	29.00	9.66	1759.76	1769.41	124.67	72.07	170.06	1966.15
44	20	2.030	2	4.93	25.92	30.00	9.66	1459.78	1469.43	74.80	72.07	165.68	1616.30
45	10	2.030	2	4.93	25.92	28.00	9.66	1731.86	1741.52	78.17	87.51	165.68	1907.20
Average				4.93	31.97	38.75	9.66	1834.23	1843.89	80.60	81.72	156.60	2006.20

Table E 1.2 Consumption of Direct and Indirect Energy Sources in Harrowing Operation by Medium Farmers

Farmer Number	Area for wheat	Rated width of harrow	No. of Operation	Man hours	Fuel		Direct Energy (MJ/ha)			Indirect Energy (MJ/ha)			Total Energy (MJ/ha)
					RHP basis	Farmer Estimate	Human	Fuel	Total	Tractor	Machinery	Total	
	(ha)			(h/ha)	(l/ha)	(l/ha)							
1	4.8	1.856	6	6.73	31.69	40.41	1784.50	13.20	1797.71	87.30	98.53	185.83	1983.53
2	4.8	1.856	7	7.86	52.81	47.14	2973.77	15.40	2989.17	87.00	114.94	201.94	3191.11
3	7.27	1.856	6	6.73	33.63	40.40	1893.97	13.20	1907.17	100.87	98.52	199.39	2106.56
4	8.08	1.856	4	4.49	19.43	26.94	1094.35	8.80	1103.15	58.19	65.68	123.87	1227.02
5	6.4	1.856	4	4.49	31.51	26.94	1774.34	8.80	1783.14	71.24	65.68	136.92	1920.06
6	4.8	1.616	4	5.16	19.14	30.95	1077.80	10.11	1087.91	61.22	64.69	125.90	1213.81
7	7.2	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	87.00	64.67	151.67	1904.04
8	4.4	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	87.00	64.67	151.67	1904.04
9	5.6	1.856	7	7.86	48.59	47.14	2735.87	15.40	2751.27	87.00	114.94	201.94	2953.21
10	9.2	1.616	4	5.16	22.62	30.95	1273.84	10.11	1283.95	62.80	64.69	127.49	1411.44
11	4.8	1.856	8	8.98	56.25	53.87	3167.49	17.60	3185.09	87.00	131.36	218.36	3403.45
12	6	1.616	6	7.74	41.59	46.43	2342.11	15.17	2357.27	94.21	97.03	191.23	2548.51
13	8	1.616	6	7.74	32.68	46.43	1840.23	15.17	1855.39	102.67	97.03	199.70	2055.10
14	4.8	1.616	6	7.74	46.41	46.41	2613.40	15.16	2628.56	87.00	97.00	184.00	2812.56
15	6	1.616	8	10.32	41.44	61.90	2333.67	20.22	2353.89	123.14	129.37	252.51	2606.40
16	6	1.856	7	7.86	49.44	47.14	2784.17	15.40	2799.56	198.83	114.94	313.77	3113.33
17	6	1.616	7	9.03	39.08	54.16	2200.51	17.69	2218.20	117.01	113.20	230.21	2448.41
18	6	1.856	7	7.86	45.67	47.14	2571.72	15.40	2587.12	198.83	114.94	313.77	2900.88
19	4.6	1.616	6	7.74	38.28	46.43	2155.60	15.17	2170.77	107.44	97.03	204.47	2375.23
20	5.6	1.856	7	7.86	42.23	47.14	2378.07	15.40	2393.47	95.65	114.94	210.59	2604.06
21	4	1.616	6	7.74	28.70	46.41	1616.20	15.16	1631.36	91.80	0.00	91.80	1723.16

22	4.8	1.856	5	5.61	34.70	33.67	1954.19	11.00	1965.19	142.02	82.10	224.12	2189.31
23	7.2	1.616	5	6.45	38.69	38.69	2178.51	12.64	2191.14	87.00	80.86	167.86	2359.00
24	8	1.616	5	6.45	51.48	38.68	2898.62	12.63	2911.26	85.09	80.00	165.09	3076.35
25	6	1.616	5	6.45	36.36	38.69	2047.24	12.64	2059.87	82.74	80.86	163.60	2223.47
26	8	1.856	5	5.61	45.99	33.67	2589.73	11.00	2600.73	78.65	82.10	160.75	2761.48
27	4.8	1.856	5	5.61	28.73	33.67	1617.73	11.00	1628.73	68.32	82.10	150.42	1779.15
28	8	1.856	5	5.61	22.63	33.67	1274.47	11.00	1285.47	87.00	82.10	169.10	1454.57
29	6	1.616	5	6.45	27.90	38.68	1571.31	12.63	1583.94	69.44	0.00	69.44	1653.38
30	6	1.402	7	10.40	51.47	62.42	2898.36	20.39	2918.75	130.58	84.80	215.38	3134.13
31	6	1.616	5	6.45	38.68	38.68	2177.83	12.63	2190.47	87.00	0.00	87.00	2277.47
32	6	1.616	6	7.74	46.41	46.41	2613.40	15.16	2628.56	87.00	0.00	87.00	2715.56
33	6	1.856	5	5.61	34.70	33.67	1954.19	11.00	1965.19	87.00	82.10	169.10	2134.29
34	6	1.616	6	7.74	0.00	46.41	0.00	15.16	15.16	87.00	0.00	87.00	102.16
35	7.6	1.856	5	5.61	38.33	33.67	2158.11	11.00	2169.11	74.08	82.10	156.18	2325.29
36	6	1.616	7	9.03	33.50	54.16	1886.15	17.69	1903.84	107.13	113.20	220.33	2124.17
37	6.8	1.856	6	6.73	31.69	40.40	1784.26	13.20	1797.46	87.28	98.52	185.80	1983.27
38	8	1.616	5	6.45	38.68	38.68	2177.83	12.63	2190.47	87.00	0.00	87.00	2277.47
39	4	1.616	5	6.45	35.53	38.68	2000.73	12.63	2013.37	78.92	0.00	78.92	2092.29
40	6	2.339	4	3.56	21.65	21.38	1218.84	6.98	1225.82	56.55	74.48	131.03	1356.85
41	9.2	2.099	4	3.97	29.48	23.82	1659.82	7.78	1667.60	66.54	70.54	137.07	1804.68
42	10	1.856	6	6.73	40.90	40.40	2303.23	13.20	2316.43	86.41	98.52	184.93	2501.36
43	7.2	1.856	7	7.86	49.84	47.14	2806.53	15.40	2821.93	198.83	114.94	313.77	3135.69
44	3	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	87.00	0.00	87.00	1839.37
45	6	1.856	4	4.49	25.31	26.94	1425.37	8.80	1434.17	57.61	65.68	123.29	1557.46
46	7.6	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	87.00	75.44	162.44	1914.82
47	4	1.856	5	5.61	33.67	33.67	1895.96	11.00	1906.96	87.00	70.37	157.37	2064.33
48	4.8	1.616	4	5.16	24.18	30.95	1361.31	10.11	1371.42	66.86	75.47	142.33	1513.75
Average				6.6	35.53	39.68	2000.72	12.96	2013.68	93.76	75.00	168.76	2182.44

Table E 1.3 Consumption of Direct and Indirect Energy Sources in Harrowing Operation by Semi Medium Farmers

Farmer Number	Area for wheat (ha)	Rated width of harrow	No. of Operation	Man hours (h/ha)	Fuel		Direct Energy (MJ/ha)			Indirect Energy (MJ/ha)			Total Energy (MJ/ha)
					RHP basis (l/ha)	Farmer Estimate (l/ha)	Human	Fuel	Total	Tractor	Machinery	Total	
1	3.2	1.856	5	5.61	22.54	33.67	1269.38	11.00	1280.38	66.60	82.10	148.69	1429.07
2	2.8	1.856	4	4.49	28.48	26.94	1603.73	8.80	1612.53	113.62	65.68	179.30	1791.83
3	4	1.856	4	4.49	31.51	26.94	1774.34	8.80	1783.14	71.24	0.00	71.24	1854.38
4	2.4	1.616	5	6.45	38.68	38.68	2177.83	12.63	2190.47	71.00	94.30	165.30	2355.77
5	2.8	1.856	6	6.73	45.99	40.40	2589.73	13.20	2602.93	71.00	98.52	169.52	2772.45
6	4	1.856	5	5.61	46.71	33.67	2630.52	11.00	2641.51	71.00	82.10	153.10	2794.61
7	4	1.616	5	6.45	38.68	38.68	2177.83	12.63	2190.47	71.00	82.00	153.00	2343.47
8	2.8	1.856	5	5.61	37.37	33.67	2104.41	11.00	2115.41	74.08	82.00	156.08	2271.49
9	2.8	1.616	5	6.45	38.68	38.68	2177.83	12.63	2190.47	71.00	82.00	153.00	2343.47
10	2.8	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	71.00	32.33	103.33	1855.71
11	3.4	1.616	7	9.02	54.15	54.15	3048.96	17.69	3066.65	71.00	132.03	203.03	3269.68
12	3.2	1.856	5	5.61	35.04	33.67	1972.89	11.00	1983.89	71.00	82.10	153.10	2136.98
13	2.8	1.856	4	4.49	19.94	26.94	1122.90	8.80	1131.70	48.36	82.00	130.36	1262.06
14	4	1.616	5	6.45	36.81	38.68	2072.95	12.63	2085.59	85.09	80.83	165.93	2251.51
15	3.23	1.616	5	6.45	36.82	38.69	2073.59	12.64	2086.23	86.44	82.00	168.44	2254.68
16	2.02	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	71.00	64.67	135.67	1888.04
17	4	1.616	5	6.45	31.91	38.69	1797.12	12.64	1809.75	80.27	82.00	162.27	1972.02
18	2	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	71.00	64.67	135.67	1888.04
19	2.4	1.616	4	5.16	19.64	30.95	1105.92	10.11	1116.03	71.00	64.69	135.69	1251.71
20	3.2	1.616	6	7.74	46.15	46.43	2598.91	15.17	2614.07	195.82	137.46	333.28	2947.35
21	2.4	1.733	4	4.81	36.16	28.86	2035.89	9.43	2045.32	71.00	70.36	141.36	2186.68
22	2.6	1.856	4	4.49	25.31	26.94	1425.37	8.80	1434.17	57.61	82.00	139.61	1573.78
23	2.8	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	71.00	75.44	146.44	1898.82

24	3.2	1.856	4	4.49	25.31	26.94	1425.37	8.80	1434.17	57.61	82.00	139.61	1573.78
25	2.8	1.616	4	5.16	19.38	30.94	1091.52	10.11	1101.63	61.55	82.00	143.55	1245.18
26	2.8	1.616	4	5.16	38.77	30.94	2183.04	10.11	2193.15	72.27	75.44	147.72	2340.87
27	4	1.856	4	4.49	24.34	26.94	1370.32	8.80	1379.11	56.19	36.59	92.79	1471.90
28	4	1.429	4	5.83	31.37	35.00	1766.20	11.43	1777.63	73.21	82.00	155.21	1932.84
29	4.8	1.616	4	5.16	25.04	30.94	1410.08	10.11	1420.18	66.84	75.44	142.28	1562.47
30	2.8	1.856	4	4.49	27.00	26.94	1520.40	8.80	1529.20	59.26	82.00	141.26	1670.46
31	3.2	1.616	5	6.45	38.68	38.68	2177.83	12.63	2190.47	71.00	94.30	165.30	2355.77
32	4	1.856	9	10.10	37.97	60.61	2138.06	19.80	2157.86	119.87	147.78	267.65	2425.51
33	2.8	1.856	5	5.61	31.64	33.67	1781.72	11.00	1792.71	142.02	82.00	224.02	2016.73
34	2.4	1.616	5	6.45	38.68	38.68	2177.83	12.63	2190.47	71.00	80.83	151.83	2342.30
35	4	1.616	5	6.45	24.24	38.69	1364.82	12.64	1377.46	76.52	94.33	170.85	1548.32
36	4	1.856	4	4.49	25.31	26.94	1425.37	8.80	1434.17	57.61	82.00	139.61	1573.78
37	2.4	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	71.00	82.00	153.00	1905.37
38	2.8	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	71.00	75.44	146.44	1898.82
39	4	1.856	5	5.61	28.83	33.67	1623.34	11.00	1634.34	68.71	82.00	150.71	1785.05
40	2.8	1.616	4	5.16	30.94	30.94	1742.26	10.11	1752.37	71.00	75.44	146.44	1898.82
41	3.6	1.856	4	4.49	28.97	26.94	1631.33	8.80	1640.13	59.26	65.68	124.94	1765.07
42	3.2	1.856	5	5.61	24.61	33.67	1385.78	11.00	1396.78	72.74	82.10	154.84	1551.61
43	2.4	1.856	4	4.49	23.63	26.94	1330.35	8.80	1339.15	54.66	65.68	120.34	1459.48
44	4	1.856	7	7.86	41.34	47.14	2328.11	15.40	2343.51	95.65	98.52	194.17	2537.68
45	3	1.616	9	11.6	69.64	69.64	3921.31	22.75	3944.06	71.00	145.54	216.54	4160.60
46	2.8	1.616	4	5.16	32.32	30.95	1819.77	10.11	1829.88	68.45	75.47	143.92	1973.79
47	4	1.856	4	4.49	22.45	26.94	1263.97	8.80	1272.77	71.00	79.75	150.75	1423.53
48	2.8	2.099	6	5.96	44.03	35.73	2479.27	11.67	2490.95	71.00	82.00	153.00	2643.95
49	2.8	1.616	6	7.74	30.94	46.41	1742.26	15.16	1757.43	71.00	97.00	168.00	1925.42
50	2.8	1.829	5	5.69	22.78	34.17	1282.63	11.16	1293.79	71.00	82.00	153.00	1446.79
Average				5.83	32.89	35.04	1851.93	11.43	1863.37	75.49	81.73	157.22	2020.59

Table E 1.4 Consumption of Direct and Indirect Energy Sources in Harrowing Operation by Small Farmers

Farmer Number	Area for wheat	Rated width of harrow	No. of Operation	Man hours	Fuel		Direct Energy (MJ/ha)			Indirect Energy (MJ/ha)			Total Energy (MJ/ha)
					RHP basis	Farmer Estimate	Human	Fuel	Total	Tractor	Machinery	Total	
	(ha)			(h/ha)	(l/ha)	(l/ha)							
1	1.2	1.616	5	6.45	25.78	38.68	1451.89	12.63	1464.52	71.00	60.00	131.00	1595.52
2	1.2	1.616	5	6.45	25.78	38.68	1451.89	12.63	1464.52	71.00	26.94	97.94	1562.47
3	0.6	1.616	6	7.74	30.94	46.41	1742.26	15.16	1757.43	71.00	60.00	131.00	1888.43
4	1.2	1.616	6	7.74	30.94	46.41	1742.26	15.16	1757.43	71.00	60.00	131.00	1888.43
5	1.4	1.616	6	7.74	30.94	46.41	1742.26	15.16	1757.43	71.00	113.17	184.17	1941.59
6	1.4	1.856	5	5.61	42.19	33.67	2375.62	11.00	2386.62	71.00	60.00	131.00	2517.62
7	2	1.616	5	6.45	25.78	38.68	1451.89	12.63	1464.52	71.00	60.00	131.00	1595.52
8	1	1.616	7	9.02	36.10	54.15	2032.64	17.69	2050.33	71.00	113.17	184.17	2234.50
9	1.2	1.616	5	6.45	42.01	38.69	2365.69	12.64	2378.33	102.32	60.00	162.32	2540.65
10	0.6	1.616	6	7.74	30.94	46.41	1742.26	15.16	1757.43	71.00	60.00	131.00	1888.43
11	1.6	1.616	6	7.74	30.94	46.41	1742.26	15.16	1757.43	71.00	97.00	168.00	1925.42
12	2	1.616	3	3.87	16.97	23.21	955.38	7.58	962.96	50.15	60.00	110.15	1073.11
13	1.2	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	71.00	75.44	146.44	1318.06
14	1.6	1.856	4	4.49	24.14	26.94	1359.44	8.80	1368.24	54.97	65.68	120.64	1488.88
15	1.7	1.856	4	4.49	19.69	26.94	1108.62	8.80	1117.42	58.19	60.00	118.19	1235.61
16	1.2	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	71.00	56.58	127.58	1006.30
17	1.6	1.856	3	3.37	20.86	20.20	1174.56	6.60	1181.16	41.45	42.22	83.68	1264.83
18	1.2	1.616	3	3.87	18.91	23.21	1064.56	7.58	1072.15	48.16	60.00	108.16	1180.31
19	1.2	1.616	3	3.87	13.41	23.21	755.40	7.58	762.98	71.00	56.58	127.58	890.56
20	1.6	1.856	3	3.37	20.25	20.20	1140.30	6.60	1146.90	44.45	60.00	104.45	1251.35

21	1.6	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	71.00	64.67	135.67	1307.28
22	2	1.616	4	5.16	22.62	30.95	1273.84	10.11	1283.95	66.86	60.00	126.86	1410.81
23	1.2	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	71.00	48.50	119.50	998.21
24	1.3	1.616	4	5.16	25.85	30.95	1455.81	10.11	1465.92	71.00	60.00	131.00	1596.92
25	1.2	1.616	5	6.45	25.78	38.68	1451.89	12.63	1464.52	71.00	60.00	131.00	1595.52
26	1.4	1.616	5	6.45	25.78	38.68	1451.89	12.63	1464.52	71.00	80.83	151.83	1616.35
27	2	1.616	4	5.16	22.62	30.95	1273.84	10.11	1283.95	71.00	60.00	131.00	1414.95
28	1.4	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	71.00	48.50	119.50	998.21
29	1	1.616	4	5.16	22.33	30.95	1257.43	10.11	1267.54	55.57	60.00	115.57	1383.12
30	0	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	71.00	60.00	131.00	1009.71
31	0	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	71.00	60.00	131.00	1009.71
32	0.2	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	71.00	60.00	131.00	1009.71
33	0	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	71.00	56.58	127.58	1006.30
34	2	1.856	3	3.37	19.15	20.20	1078.21	6.60	1084.80	85.21	60.00	145.21	1230.02
35	2	1.616	3	3.87	19.56	23.21	1101.23	7.58	1108.81	71.00	48.51	119.51	1228.33
36	1.2	1.616	7	9.02	36.10	54.15	2032.64	17.69	2050.33	71.00	60.00	131.00	2181.33
37	1.8	1.856	3	3.37	21.02	20.20	1183.73	6.60	1190.33	44.45	49.26	93.71	1284.04
38	1.6	1.616	5	6.45	25.78	38.68	1451.89	12.63	1464.52	71.00	60.00	131.00	1595.52
39	1.6	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	71.00	60.00	131.00	1302.62
40	1.6	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	71.00	60.00	131.00	1302.62
41	1.6	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	71.00	60.00	131.00	1302.62
42	1.5	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	71.00	60.00	131.00	1302.62
Average				5.33	23.46	32.00	1320.92	10.45	1331.37	67.92	61.99	129.91	1461.29

Table E 1.5 Consumption of Direct and Indirect Energy Sources in Harrowing Operation by Marginal Farmers

Farmer Number	Area for wheat	Rated width of harrow	No. of Operation	Man hours	Fuel		Direct Energy (MJ/ha)			Indirect Energy (MJ/ha)			Total Energy (MJ/ha)
					RHP basis	Farmer Estimate	Human	Fuel	Total	Tractor	Machinery	Total	
	(ha)			(h/ha)	(l/ha)	(l/ha)							
1	0.4	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	50.00	55.00	105.00	1276.62
2	0.8	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	50.00	55.00	105.00	1276.62
3	0.8	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	50.00	55.00	105.00	983.71
4	0.2	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	50.00	55.00	105.00	1276.62
5	0.8	1.616	4	5.16	22.32	30.94	1257.05	10.11	1267.15	68.43	64.67	133.09	1400.24
6	1	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	60.00	55.00	115.00	1286.62
7	0.4	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	60.00	55.00	115.00	993.71
8	0.4	1.616	4	5.16	24.26	30.94	1366.35	10.11	1376.46	66.84	55.00	121.84	1498.30
9	0.4	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	50.00	55.00	105.00	983.71
10	0.8	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	50.00	66.00	116.00	1287.62
11	0.6	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	50.00	56.00	106.00	984.71
12	0.2	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	50.00	65.00	115.00	993.71
13	0.4	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	50.00	56.00	106.00	984.71
14	0.8	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	50.00	65.00	115.00	993.71
15	0.3	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	50.00	66.00	116.00	1287.62
16	0.8	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	50.00	56.00	106.00	984.71
17	0.6	1.616	3	3.87	13.47	23.21	758.33	7.58	765.91	46.29	48.50	94.79	860.70
18	0.4	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	46.00	56.00	102.00	1273.62
19	0.8	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	46.00	66.00	112.00	1283.62
20	1	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	46.00	45.00	91.00	969.71

21	1	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	46.00	45.00	91.00	969.71
22	1	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	46.00	45.00	91.00	1262.62
23	0.4	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	46.00	45.00	91.00	1262.62
24	0.2	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	46.00	55.00	101.00	1272.62
25	0.3	1.616	7	9.02	36.10	54.15	2032.64	17.69	2050.33	46.00	55.00	101.00	2151.33
26	0.3	1.616	4	5.16	22.81	30.94	1284.37	10.11	1294.48	66.49	64.67	131.15	1425.63
27	0.2	1.616	7	9.02	36.10	54.15	2032.64	17.69	2050.33	66.49	44.00	110.49	2160.82
28	0.4	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	66.49	45.00	111.49	1283.11
29	0.6	1.616	4	5.16	20.72	30.94	1166.48	10.11	1176.58	61.20	64.67	125.86	1302.44
30	0.6	1.616	7	9.02	36.10	54.15	2032.64	17.69	2050.33	61.20	45.00	106.20	2156.53
31	0.8	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	61.20	45.00	106.20	1277.82
32	0.4	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	61.20	45.00	106.20	1277.82
33	0.9	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	61.20	45.00	106.20	1277.82
34	1	1.616	6	7.74	36.40	46.41	2049.53	15.16	2064.69	100.26	45.00	145.26	2209.95
35	0.4	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	70.00	45.00	115.00	1286.62
36	0.3	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	70.00	55.00	125.00	1296.62
37	0.6	1.616	5	6.45	25.78	38.68	1451.89	12.63	1464.52	70.00	55.00	125.00	1589.52
38	1	1.616	4	5.16	20.63	30.94	1161.51	10.11	1171.62	70.00	55.00	125.00	1296.62
39	0.8	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	70.00	55.00	125.00	1003.71
40	0.8	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	70.00	55.00	125.00	1003.71
41	1	1.616	3	3.87	15.47	23.21	871.13	7.58	878.71	70.00	55.00	125.00	1003.71
Average				5.09	20.65	30.56	1162.53	9.98	1172.52	57.69	53.99	111.68	1284.19

Table E 2.1 Consumption of Direct and Indirect Energy Sources in Planking Operation by Large Farmers

Farmer Number	Area under wheat ha	No of Operation	Man hour h/ha	Fuel l/ha	Direct Energy			Indirect Energy			Total Energy MJ/ha
					Fuel Energy	Human Energy	Total	Tractor	Machinery	Total	
					MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	
1	12	5	3.20	10.81	608.51	3.88	612.38	27.72	4.13	31.85	644.24
2	24	3	2.00	16.38	343.00	6.42	349.42	27.72	6.85	34.57	383.99
3	40	5	3.25	14.95	841.93	6.26	848.19	50.71	6.68	57.38	905.57
4	10	4	2.25	11.63	655.15	5.14	660.28	34.59	5.48	40.07	700.35
5	10	4	3.00	11.38	641.04	5.03	646.06	33.85	5.36	39.21	685.27
6	2.4	3	2.75	5.82	327.94	3.62	331.56	29.34	3.86	33.21	364.77
7	7.2	3	3.20	9.32	525.06	3.88	528.93	26.25	4.13	30.38	559.31
8	10	2	2.00	6.59	343.00	2.58	345.58	26.25	2.76	29.01	374.59
9	12	4	3.25	10.04	565.38	5.17	570.55	34.81	5.51	40.32	610.88
10	6	4	2.25	12.56	707.04	5.14	712.18	34.59	5.48	40.07	752.25
11	16	4	3.00	12.64	711.52	5.17	716.69	34.81	5.51	40.32	757.01
12	15.2	4	2.75	8.21	462.38	5.01	467.39	28.76	5.34	34.10	501.49
13	10	2	3.20	6.10	343.38	2.58	345.97	17.27	2.76	20.03	365.99
14	6	4	2.00	5.75	323.68	5.17	328.85	33.10	5.51	38.61	367.46
15	8	3	3.25	8.65	487.22	3.62	490.85	29.34	3.86	33.21	524.05
16	3.2	3	2.25	8.23	463.57	3.88	467.44	25.38	4.13	29.51	496.96
17	20	3	3.00	7.54	424.60	3.55	428.15	23.25	3.79	27.03	455.18
18	66	3	2.75	8.23	463.57	3.88	467.44	25.38	4.13	29.51	496.96
19	15.2	3	3.20	5.91	332.60	3.88	336.48	23.47	4.13	27.61	364.08
20	5.2	3	2.00	9.89	332.00	3.88	335.88	23.47	4.13	27.60	363.48
21	24	3	3.20	9.75	549.01	3.88	552.89	27.72	4.13	31.85	584.74
22	14	3	2.00	8.78	494.47	3.88	498.35	26.11	4.13	30.24	528.59
23	12.8	3	3.20	10.76	606.11	3.88	609.99	27.72	4.13	31.85	641.84

24	20	3	2.00	8.39	472.55	3.88	476.43	27.72	4.13	31.85	508.28
25	14	2	3.20	6.22	350.04	2.58	352.62	17.50	2.76	20.25	372.87
26	10	2	2.00	4.73	266.08	2.58	268.67	16.05	2.76	18.81	287.48
27	60	4	3.25	13.05	734.94	5.17	740.11	41.85	5.51	47.36	787.47
28	12	2	2.25	4.96	279.10	2.58	281.68	16.92	2.76	19.68	301.36
29	9.2	2	3.00	4.96	279.10	2.58	281.68	16.92	2.76	19.68	301.36
30	16	3	2.75	8.90	501.10	3.88	504.97	24.76	4.13	28.89	533.87
31	16.8	3	3.20	7.43	418.65	3.88	422.52	25.38	4.13	29.51	452.04
32	18	5	2.00	12.39	697.74	6.46	704.21	42.30	6.89	49.19	753.39
33	14.8	4	3.25	11.71	659.29	5.17	664.46	34.81	5.51	40.32	704.79
34	16	4	2.25	8.27	465.83	5.17	471.00	34.54	5.51	40.05	511.05
35	20	4	3.00	7.91	279.00	5.17	284.17	38.60	5.51	44.11	328.28
36	19.2	4	2.75	12.34	694.86	5.17	700.03	41.85	5.51	47.36	747.38
37	9.2	4	1.98	14.41	811.34	5.17	816.51	36.96	5.51	42.47	858.98
38	24	2	2.00	5.49	309.04	2.58	311.63	17.41	2.76	20.16	331.79
39	28	2	3.25	5.51	310.11	2.58	312.69	16.92	2.76	19.68	332.37
40	28.8	4	2.25	13.05	734.94	5.17	740.11	41.85	5.51	47.36	787.47
41	12	4	3.00	10.98	618.09	5.17	623.26	34.81	5.51	40.32	663.58
42	16	4	2.75	13.53	761.67	5.17	766.84	44.19	5.51	49.70	816.54
43	20	4	1.98	13.05	734.94	5.17	740.11	41.85	5.51	47.36	787.47
44	10	4	2.20	7.91	279.00	5.17	284.17	66.74	5.51	72.25	356.42
45	10.4	4	1.98	9.25	520.98	5.17	526.15	40.04	5.51	45.56	571.71
Average			2.65	9.43	505.12	4.33	509.46	30.92	4.62	35.54	545.00

Table E 2.2 Consumption of Direct and Indirect Energy Sources in Planking Operation by Medium Farmers

Farmer Number	Area under wheat ha	No of Operation	Man hour h/ha	Fuel l/ha	Direct Energy			Indirect Energy			Total Energy MJ/ha
					Fuel Energy	Human Energy	Total	Tractor	Machinery	Total	
					MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	
1	3.4	4	3.20	8.27	465.83	5.17	471.00	34.18	5.51	39.69	510.69
2	4	4	2.00	7.91	279.00	5.17	284.17	40.04	5.51	45.55	329.72
3	4.8	3	3.25	6.59	370.85	3.88	374.73	29.63	4.13	33.76	408.49
4	7	2	2.25	3.81	214.28	2.58	216.87	17.09	2.76	19.85	236.71
5	6.4	2	3.00	6.17	347.43	2.58	350.01	20.92	2.76	23.68	373.69
6	4.8	2	2.75	3.26	183.67	2.58	186.25	15.65	2.76	18.40	204.66
7	3.6	3	3.20	5.93	279.00	3.88	282.88	15.65	4.13	19.78	302.66
8	1	3	2.00	5.93	222.00	3.88	225.88	15.65	4.13	19.78	245.66
9	3.2	4	3.25	7.91	214.00	5.17	219.17	15.65	5.51	21.16	240.33
10	5.6	2	2.25	3.86	217.08	2.58	219.66	16.05	2.76	18.81	238.47
11	2.8	4	3.00	7.91	214.00	5.17	219.17	16.05	5.51	21.56	240.73
12	6	4	2.75	9.45	532.16	5.17	537.33	32.11	5.51	37.62	574.95
13	3.2	4	3.20	7.91	214.00	5.17	219.17	34.99	5.51	40.51	259.67
14	3.2	4	2.00	7.91	214.00	5.17	219.17	16.05	5.51	21.56	240.73
15	4	4	3.25	7.06	397.68	5.17	402.85	31.48	5.51	36.99	439.84
16	3.6	4	2.25	7.91	214.00	5.17	219.17	66.74	5.51	72.25	291.42
17	4	4	3.00	7.61	428.56	5.17	433.73	34.18	5.51	39.69	473.42
18	3.2	4	2.75	7.91	214.00	5.17	219.17	66.74	5.51	72.25	291.42
19	4	4	3.20	8.70	489.79	5.17	494.95	36.62	5.51	42.13	537.08
20	5.6	4	2.00	9.45	532.16	5.17	537.33	32.11	5.51	37.62	574.95
21	4	3	3.25	4.89	275.50	3.88	279.38	23.47	4.13	27.61	306.99
22	4.8	3	2.25	5.93	214.00	3.88	217.88	50.06	4.13	54.19	272.07
23	6.4	3	3.00	5.93	214.00	3.88	217.88	23.47	4.13	27.60	245.48

24	6	3	2.75	10.53	592.93	3.88	596.81	26.11	4.13	30.24	627.05
25	5.6	5	1.98	12.39	697.74	6.46	704.21	42.30	6.89	49.19	753.39
26	3.2	5	3.20	18.01	297.00	6.46	303.46	46.20	6.89	53.09	356.55
27	2.2	5	2.00	11.25	633.53	6.46	639.99	40.13	6.89	47.02	687.01
28	6	4	3.20	7.09	399.28	5.17	404.45	14.30	5.51	19.81	424.26
29	6	2	2.00	3.81	214.28	2.58	216.87	14.20	2.76	16.96	233.83
30	3.2	4	3.25	7.91	214.00	5.17	219.17	33.10	5.51	38.61	257.78
31	6	3	2.25	5.93	214.00	3.88	217.88	33.10	4.13	37.23	255.11
32	6	5	3.00	9.89	214.00	6.46	220.46	33.10	6.89	39.99	260.45
33	4	5	2.75	9.89	214.00	6.46	220.46	33.10	6.89	39.99	260.45
34	4	5	3.20	9.89	214.00	6.46	220.46	33.10	6.89	39.99	260.45
35	3	5	2.00	15.01	845.15	6.46	851.61	43.52	6.89	50.41	902.01
36	4.8	5	3.25	8.15	459.17	6.46	465.63	39.12	6.89	46.01	511.64
37	6.8	4	2.25	8.27	465.83	5.17	471.00	34.18	5.51	39.69	510.69
38	7.6	4	3.00	7.91	214.00	5.17	219.17	34.18	5.51	39.69	258.86
39	7	2	2.75	3.96	255.00	2.58	257.58	16.14	2.76	18.90	276.48
40	5.8	2	1.98	5.34	300.66	2.58	303.24	20.92	2.76	23.68	326.92
41	8.8	2	2.00	6.53	367.47	2.58	370.06	22.10	2.76	24.85	394.91
42	8.8	4	3.25	7.91	244.00	5.17	249.17	33.84	5.51	39.35	288.52
43	7.2	4	2.25	7.91	212.00	5.17	217.17	66.74	5.51	72.25	289.42
44	3	5	3.00	9.89	212.00	6.46	218.46	22.00	6.89	28.89	247.35
45	4	5	2.75	12.39	244.00	6.46	250.46	42.30	6.89	49.19	299.65
46	4	5	1.98	9.89	244.00	6.46	250.46	42.90	6.89	49.79	300.25
47	4	2	2.20	3.96	244.00	2.58	246.58	42.90	2.76	45.66	292.24
48	4.8	2	2.20	4.12	231.98	2.58	234.57	17.09	2.76	19.85	254.41
Average			2.66	7.83	320.65	4.71	325.36	31.48	5.02	36.51	361.86

Table E 2.3 Consumption of Direct and Indirect Energy Sources in Planking Operation by Semi Medium Farmers

Farmer Number	Area under wheat ha	No. of Operation	Man hour h/ha	Fuel l/ha	Direct Energy			Indirect Energy			Total Energy MJ/ha
					Fuel Energy	Human Energy	Total	Tractor	Machinery	Total	
					MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	
1	1.4	4	3.20	7.91	244.00	5.17	249.17	31.30	5.51	36.81	285.98
2	2.8	4	2.00	11.15	222.00	5.17	227.17	66.74	5.51	72.25	299.42
3	2.4	4	3.25	7.25	222.00	4.73	226.73	38.33	5.05	43.38	270.11
4	2.4	3	2.25	5.93	244.00	3.88	247.88	16.00	4.13	20.13	268.01
5	2.4	3	3.00	5.93	244.00	3.88	247.88	17.00	4.13	21.13	269.01
6	4	3	2.75	10.98	244.00	3.88	247.88	17.00	4.13	21.13	269.01
7	2.4	3	3.20	5.93	350.00	3.88	353.88	26.11	4.13	30.24	384.12
8	2.8	3	2.00	5.93	350.00	3.88	353.88	26.00	4.13	30.13	384.01
9	2.8	5	3.25	9.89	350.00	6.46	356.46	26.00	6.89	32.89	389.35
10	2.4	4	2.25	7.91	350.00	5.17	355.17	26.00	5.51	31.51	386.68
11	2.4	4	3.00	7.91	350.00	5.17	355.17	26.00	5.51	31.51	386.68
12	2.8	5	2.75	9.76	549.68	6.46	556.14	35.51	6.89	42.40	598.54
13	2.5	2	3.20	3.96	454.00	2.58	456.58	17.41	2.76	20.16	476.75
14	3.2	2	2.00	3.96	454.00	2.58	456.58	17.68	2.76	20.43	477.02
15	2	2	3.25	3.96	454.00	2.58	456.58	17.00	2.76	19.76	476.34
16	2	2	2.25	3.96	454.00	2.58	456.58	16.41	2.76	19.17	475.75
17	1.6	2	3.00	3.96	454.00	2.58	456.58	17.00	2.76	19.76	476.34
18	2.4	3	2.75	5.93	454.00	3.88	457.88	17.00	4.13	21.13	479.01
19	2.8	4	3.20	7.91	454.00	5.17	459.17	66.74	5.51	72.25	531.42
20	0.8	2	2.00	6.61	372.13	2.58	374.71	17.00	2.76	19.76	394.47
21	2.6	4	3.25	7.69	372.00	5.03	377.03	32.90	5.36	38.26	415.29
22	2.4	4	2.25	7.91	372.00	5.17	377.17	32.00	5.51	37.51	414.68
23	2	4	3.00	7.91	372.00	5.17	377.17	33.84	5.51	39.35	416.52

24	2	3	2.75	5.93	372.00	3.88	375.88	23.61	4.13	27.74	403.62
25	0.8	3	1.98	5.93	372.00	3.88	375.88	27.72	4.13	31.85	407.73
26	4	2	3.20	2.87	161.84	2.58	164.43	16.50	2.76	19.26	183.69
27	4	2	2.00	4.73	266.19	2.58	268.77	16.55	2.76	19.31	288.08
28	2.4	2	3.20	4.27	240.37	2.58	242.95	17.09	2.76	19.85	262.80
29	2.4	2	2.00	3.96	240.00	2.58	242.58	17.41	2.76	20.16	262.75
30	3.2	2	3.25	3.96	240.00	2.58	242.58	32.00	2.76	34.76	277.34
31	2	5	2.25	9.89	240.00	6.46	246.46	39.12	6.89	46.01	292.47
32	1.2	5	3.00	9.89	240.00	6.46	246.46	83.43	6.89	90.32	336.78
33	2.4	4	2.75	7.91	240.00	5.17	245.17	32.00	5.51	37.51	282.68
34	1.6	4	3.20	6.61	372.13	5.17	377.30	31.30	5.51	36.81	414.11
35	3.4	2	2.00	3.96	372.00	2.58	374.58	16.92	2.76	19.68	394.26
36	2.4	2	3.25	3.96	372.00	2.58	374.58	32.00	2.76	34.76	409.34
37	0.4	2	2.25	3.96	372.00	2.58	374.58	32.00	2.76	34.76	409.34
38	4	3	3.00	5.93	372.00	3.88	375.88	24.22	4.13	28.35	404.23
39	2.8	5	2.75	9.89	372.00	6.46	378.46	32.00	6.89	38.89	417.35
40	3.6	4	1.98	11.35	638.85	5.17	644.02	34.81	5.51	40.32	684.34
41	3.2	4	1.98	7.71	434.15	5.17	439.32	34.18	5.51	39.69	479.01
42	2.4	2	2.40	4.63	260.49	2.58	263.08	16.05	2.76	18.81	281.89
43	4	4	2.05	7.91	260.00	5.17	265.17	32.11	5.51	37.62	302.79
44	2.8	5	1.95	9.89	260.00	6.46	266.46	32.00	6.89	38.89	305.35
45	2.8	2	2.80	3.75	260.00	2.45	262.45	16.60	2.62	19.22	281.67
46	4	2	1.80	3.96	260.00	2.58	262.58	16.60	2.76	19.36	281.94
47	2.2	4	2.20	7.69	260.00	5.03	265.03	16.60	5.36	21.96	286.98
48	2.4	4	2.15	7.91	260.00	5.17	265.17	16.60	5.51	22.11	287.28
Average			3	6.62	334.36	4.15	338.51	27.41	4.42	31.83	370.35

Table E 2.4 Consumption of Direct and Indirect Energy Sources in Planking Operation by Small Farmers

Farmer Number	Area under wheat ha	No of Operation	Man hour h/ha	Fuel l/ha	Direct Energy			Indirect Energy			Total Energy MJ/ha
					Fuel Energy MJ/ha	Human Energy MJ/ha	Total MJ/ha	Tractor MJ/ha	Machinery MJ/ha	Total MJ/ha	
1	1.2	3	2.00	5.93	260.00	3.88	263.88	16.60	4.13	20.73	284.61
2	1.2	3	3.25	5.93	260.00	3.88	263.88	16.60	4.13	20.73	284.61
3	0.6	3	2.25	5.93	260.00	3.88	263.88	16.60	4.13	20.73	284.61
4	1.2	3	3.00	5.93	260.00	3.88	263.88	16.60	4.13	20.73	284.61
5	1.4	3	2.75	5.93	260.00	3.88	263.88	16.60	4.13	20.73	284.61
6	1.4	3	3.20	5.93	260.00	3.88	263.88	16.60	4.13	20.73	284.61
7	2	3	2.00	7.91	260.00	3.88	263.88	16.60	4.13	20.73	284.61
8	1	4	3.25	7.91	260.00	5.17	265.17	16.60	5.51	22.11	287.28
9	1.2	5	2.25	12.90	260.00	6.32	266.32	51.18	6.74	57.92	324.24
10	0.6	3	3.00	5.93	260.00	3.88	263.88	17.09	4.13	21.22	285.10
11	1.6	3	2.75	7.91	260.00	3.88	263.88	17.09	4.13	21.22	285.10
12	2	2	3.20	5.27	260.00	2.58	262.58	17.09	2.76	19.85	282.43
13	1.2	2	2.00	5.27	260.00	2.58	262.58	17.09	2.76	19.85	282.43
14	1.6	2	3.25	4.73	266.19	2.58	268.77	16.14	2.76	18.90	287.67
15	1.7	2	2.25	5.27	266.19	2.58	268.77	17.09	2.76	19.85	288.62
16	1.2	3	3.00	7.91	266.19	3.88	270.07	0.00	4.13	4.13	274.20
17	1.6	3	2.75	7.92	445.86	3.76	449.62	17.09	4.01	21.10	470.72
18	1.2	3	3.20	7.91	266.19	3.88	270.07	24.62	4.13	28.76	298.82
19	1.2	3	2.00	4.57	257.54	3.88	261.41	24.61	4.13	28.74	290.16
20	1.6	3	3.25	7.91	257.54	3.88	261.42	26.11	4.13	30.24	291.66
21	1.6	2	2.25	5.27	257.54	2.58	260.12	26.11	2.76	28.87	288.99

22	2	2	3.00	5.27	257.54	2.58	260.12	17.09	2.76	19.85	279.97
23	1.2	4	2.75	10.55	257.54	5.17	262.71	26.11	5.51	31.62	294.33
24	1.3	2	1.98	5.27	257.54	2.58	260.12	26.11	2.76	28.87	288.99
25	1.2	3	3.20	7.91	257.54	3.88	261.42	26.11	4.13	30.24	291.66
26	1.4	3	2.00	7.91	257.54	3.88	261.42	26.11	4.13	30.24	291.66
27	2	2	3.20	5.27	257.54	2.58	260.12	26.11	2.76	28.87	288.99
28	1.4	2	2.00	5.27	257.54	2.58	260.12	26.11	2.76	28.87	288.99
29	1	2	3.25	5.27	257.54	2.58	260.12	14.20	2.76	16.96	277.09
30	0	4	2.25	10.55	257.54	5.17	262.71	14.20	5.51	19.71	282.42
31	0	4	3.00	7.91	257.54	5.17	262.71	14.20	5.51	19.71	282.42
32	0.2	4	2.75	7.91	257.54	5.17	262.71	14.20	5.51	19.71	282.42
33	0	4	3.20	7.91	257.54	5.17	262.71	14.20	5.51	19.71	282.42
34	2	4	2.00	7.91	257.54	5.17	262.71	66.74	5.51	72.25	334.96
35	2	5	3.25	9.89	257.54	6.46	264.00	16.70	6.89	23.59	287.59
36	1.2	5	2.25	9.89	257.54	6.46	264.00	16.70	6.89	23.59	287.59
37	1.8	4	3.00	10.98	618.09	5.17	623.26	34.81	5.51	40.32	663.58
38	1.6	4	2.75	10.55	257.12	5.17	262.29	16.70	5.51	22.21	284.50
39	1.6	2	1.98	5.27	257.12	2.58	259.70	16.70	2.76	19.46	279.16
40	1.6	2	1.98	5.27	257.12	2.58	259.70	16.70	2.76	19.46	279.16
41	1.6	3	2.40	7.91	257.12	3.88	261.00	16.70	4.13	20.83	281.83
42	1.5	2	1.50	5.27	257.12	2.58	259.70	16.70	2.76	19.46	279.16
Average			2.63	7.15	272.14	3.93	276.08	20.65	4.19	24.84	300.92

Table E 2.5 Consumption of Direct and Indirect Energy Sources in Planking Operation by Marginal Farmers

Farmer Number	Area under wheat	No of Operation	Man hour	Fuel	Direct Energy			Indirect Energy			Total Energy
					Fuel Energy	Human Energy	Total	Tractor	Machinery	Total	
	ha		h/ha	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha
1	0.4	3	2.00	5.93	257.12	3.88	261.00	16.70	4.13	20.83	281.83
2	0.8	3	3.25	5.93	257.12	3.88	261.00	16.70	4.13	20.83	281.83
3	0.8	3	2.25	5.93	257.12	3.88	261.00	16.70	4.13	20.83	281.83
4	0.2	3	3.00	5.93	257.12	3.88	261.00	16.70	4.13	20.83	281.83
5	0.8	3	2.75	5.71	321.42	3.88	325.30	26.25	4.13	30.38	355.68
6	1	3	3.20	5.93	257.13	3.88	261.01	26.25	4.13	30.38	291.39
7	0.4	3	2.00	5.93	257.13	3.88	261.01	26.25	4.13	30.38	291.39
8	0.4	5	3.25	10.34	582.29	6.46	588.75	42.73	6.89	49.62	638.36
9	0.4	3	2.25	7.91	257.13	3.88	261.01	26.25	4.13	30.38	291.39
10	0.8	3	3.00	5.93	257.13	3.88	261.01	26.25	4.13	30.38	291.39
11	0.6	3	2.75	6.92	257.13	3.88	261.01	26.25	4.13	30.38	291.39
12	0.2	2	3.20	3.96	257.13	2.58	259.71	26.25	2.76	29.01	288.72
13	0.4	2	2.00	3.96	257.13	2.58	259.71	26.25	2.76	29.01	288.72
14	0.8	2	3.25	3.96	257.13	2.58	259.71	26.25	2.76	29.01	288.72
15	0.3	2	2.25	3.96	257.13	2.58	259.71	26.25	2.76	29.01	288.72
16	0.8	2	3.00	2.64	257.13	2.58	259.71	26.25	2.76	29.01	288.72
17	0.6	2	2.75	3.06	172.36	2.58	174.94	15.78	2.76	18.54	193.48
18	0.4	3	3.20	5.93	172.36	3.88	176.24	15.78	4.13	19.91	196.15
19	0.8	2	2.00	3.96	172.36	2.58	174.94	15.78	2.76	18.54	193.48

20	1	3	3.25	5.93	172.36	3.88	176.24	15.78	4.13	19.91	196.15
21	1	3	2.25	5.93	172.36	3.88	176.24	15.78	4.13	19.91	196.15
22	1	3	3.00	5.93	172.36	3.88	176.24	15.78	4.13	19.91	196.15
23	0.4	4	2.75	7.91	172.36	5.17	177.53	15.78	5.51	21.29	198.82
24	0.2	4	1.98	7.91	172.36	5.17	177.53	15.78	5.51	21.29	198.82
25	0.3	4	3.20	7.91	172.36	5.17	177.53	15.78	5.51	21.29	198.82
26	0.3	4	2.00	10.55	172.36	5.17	177.53	34.00	5.51	39.51	217.04
27	0.2	4	3.20	10.55	172.36	5.17	177.53	15.78	5.51	21.29	198.82
28	0.4	2	2.00	5.27	172.36	2.58	174.94	15.78	2.76	18.54	193.48
29	0.6	2	3.25	3.53	198.84	2.58	201.43	15.65	2.76	18.40	219.83
30	0.6	4	2.25	7.07	198.84	5.17	204.01	15.65	5.51	21.16	225.17
31	0.8	2	3.00	3.53	198.84	2.58	201.42	15.65	2.76	18.41	219.83
32	0.4	2	2.75	3.53	198.84	2.58	201.42	15.65	2.76	18.41	219.83
33	0.9	5	3.20	8.83	198.84	6.46	205.30	15.65	6.89	22.54	227.84
34	1	4	2.00	8.27	465.83	5.17	471.00	34.18	5.51	39.69	510.69
35	0.4	4	3.25	9.07	198.34	5.17	203.51	34.18	5.51	39.69	243.20
36	0.3	4	2.25	9.07	198.34	5.17	203.51	34.18	5.51	39.69	243.20
37	0.6	4	3.00	9.07	198.34	5.17	203.51	34.18	5.51	39.69	243.20
38	1	2	2.75	4.54	198.34	2.58	200.92	34.18	2.76	36.94	237.86
39	0.8	3	1.98	6.80	198.34	3.88	202.22	15.78	4.13	19.91	222.13
40	0.8	4	1.98	9.07	198.34	5.17	203.51	15.78	5.51	21.29	224.80
41	1	4	2.40	7.07	198.34	5.17	203.51	15.78	5.51	21.29	224.80
Average			2.66	6.37	229.76	4.00	233.76	22.01	4.27	26.28	260.04

Table E 3.1 Consumption of Direct and Indirect Energy Sources in Sowing operation by Large Farmers

Farmer No.	Area for Wheat (ha)	Rated width of drill (m)	Man Hours	Fuel consumption RHP Basis	Direct Energy MJ/ha			Indirect Energy (MJ/ha)				Total Energy
			(h/ha)	(l/ha)	Fuel	Human	Total	Seed	Tractor	Machinery	Total	(MJ/ha)
1	12	2.2	2.60	10.64	599.34	5.09	604.43	2435.00	18.20	14.25	2467.45	3071.88
2	24	2.2	2.60	7.79	438.78	5.09	443.87	2435.00	18.00	14.25	2467.25	2911.12
3	40	2.2	2.60	8.76	493.55	5.09	498.64	2435.00	20.61	14.25	2469.86	2968.50
4	10	2.2	2.60	8.65	487.02	5.09	492.11	2435.00	17.14	14.25	2466.39	2958.51
5	10	2.2	2.60	8.65	487.02	5.09	492.11	2435.00	17.14	14.25	2466.39	2958.51
6	2.4	2.2	2.60	9.64	542.90	5.09	548.00	2435.00	20.61	14.25	2469.86	3017.85
7	7.2	2.2	2.60	9.18	517.15	5.09	522.24	2435.00	17.23	14.25	2466.48	2988.72
8	10	2.2	2.60	7.79	438.78	5.09	443.87	2678.50	18.00	14.25	2710.75	3154.62
9	12	2.2	2.60	7.42	417.65	5.09	422.74	2678.50	17.14	14.25	2709.89	3132.63
10	6	2.2	2.60	10.37	584.00	5.09	589.09	2678.50	17.14	14.25	2709.89	3298.99
11	16	1.8	3.17	12.68	713.78	6.22	720.00	2678.50	20.95	14.93	2714.38	3434.38
12	15.2	2.2	2.60	5.62	316.58	5.09	321.67	2678.50	14.61	14.25	2707.36	3029.03
13	10	2.2	2.60	9.01	507.31	5.09	512.40	2435.00	17.01	14.25	2466.26	2978.67
14	6	2.2	2.60	7.79	438.78	5.09	443.87	2435.00	16.30	14.25	2465.55	2909.42
15	8	2.2	2.60	9.64	542.90	5.09	548.00	2435.00	20.61	14.25	2469.86	3017.85
16	3.2	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	16.66	14.25	2465.91	2927.59
17	20	2.6	2.20	6.86	386.34	4.31	390.65	2435.00	14.10	13.78	2462.88	2853.53
18	66	2.6	2.20	8.39	472.19	4.31	476.50	2435.00	14.10	13.78	2462.88	2939.38
19	15.2	2.2	2.60	5.82	327.59	5.09	332.68	2435.00	15.41	14.25	2464.66	2797.34
20	5.2	2.2	2.60	7.79	438.78	5.09	443.87	2435.00	18.00	14.25	2467.25	2911.12
21	24	2.2	2.60	9.60	540.74	5.09	545.83	2435.00	18.20	14.25	2467.45	3013.28

22	14	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	17.14	14.25	2466.39	2928.07
23	12.8	2.2	2.60	10.60	596.98	5.09	602.07	2435.00	18.20	14.25	2467.45	3069.52
24	20	2.2	2.60	11.02	620.57	5.09	625.67	2435.00	18.20	14.25	2467.45	3093.12
25	14	2.6	2.20	6.99	393.83	4.31	398.13	2435.00	14.58	13.78	2463.36	2861.50
26	10	2.2	2.60	7.48	421.19	5.09	426.28	2435.00	15.81	14.25	2465.06	2891.34
27	60	2.6	2.20	8.35	470.36	4.31	474.67	2435.00	17.44	13.78	2466.22	2940.89
28	12	2.2	2.60	7.32	412.34	5.09	417.43	2922.00	16.66	14.25	2952.91	3370.35
29	9.2	2.2	2.60	7.32	412.34	5.09	417.43	2922.00	16.66	14.25	2952.91	3370.35
30	16	2.2	2.60	8.97	505.35	5.09	510.44	2191.50	16.26	14.25	2222.01	2732.44
31	16.8	2.2	2.60	7.32	412.34	5.09	417.43	2191.50	16.66	14.25	2222.41	2639.85
32	18	2.2	2.60	7.32	412.34	5.09	417.43	2435.00	16.66	14.25	2465.91	2883.35
33	14.8	2.2	2.60	8.11	456.58	5.09	461.67	2191.50	17.14	14.25	2222.89	2684.57
34	16	2.2	2.60	8.97	505.35	5.09	510.44	2191.50	17.01	14.25	2222.76	2733.20
35	20	2.2	2.60	7.79	438.78	5.09	443.87	2435.00	19.01	14.25	2468.26	2912.13
36	19.2	2.2	2.60	9.64	542.90	5.09	548.00	2435.00	20.61	14.25	2469.86	3017.85
37	9.2	1.8	3.17	13.01	732.52	6.22	738.75	2678.50	22.25	14.93	2715.67	3454.42
38	24	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	17.14	14.25	2466.39	2928.07
39	28	2.2	2.60	8.14	458.16	5.09	463.25	2435.00	16.66	14.25	2465.91	2929.16
40	28.8	1.8	3.17	0.00	0.00	6.22	6.22	2191.50	25.19	14.93	2231.62	2237.84
41	12	2.2	2.60	8.11	456.58	5.09	461.67	2191.50	17.14	14.25	2222.89	2684.57
42	16	2.2	2.60	11.39	641.61	5.09	646.71	2191.50	21.76	14.25	2227.51	2874.22
43	20	2.2	2.60	7.79	438.78	5.09	443.87	2191.50	20.61	14.25	2226.36	2670.23
44	10	2.2	2.60	7.79	438.78	5.09	443.87	2191.50	32.87	14.25	2238.62	2682.49
45	10.4	2.2	2.60	8.11	456.58	5.09	461.67	2191.50	19.72	14.25	2225.47	2687.14
	Average		2.60	8.40	473.00	5.10	478.10	2435.00	18.19	14.25	2467.44	2945.55

Table E 3.2 Consumption of Direct and Indirect Energy Sources in Sowing operation by Medium Farmers

Farmer No.	Area for Wheat (ha)	Rated width of drill (m)	Man Hours (h/ha)	Fuel consumption RHP Basis (l/ha)	Direct Energy MJ/ha			Indirect Energy (MJ/ha)				Total Energy (MJ/ha)
					Fuel	Human	Total	Seed	Tractor	Machinery	Total	
Farmers using seed cum ferti drill												
1	3.4	2.2	2.60	11.35	639.06	5.09	644.15	2191.50	16.83	14.25	2222.58	2866.73
2	4	2.2	2.60	9.01	507.31	5.09	512.40	2435.00	15.99	14.25	2465.24	2977.64
3	4.8	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	19.45	14.25	2468.70	2930.38
4	7	1.8	3.17	6.87	386.93	6.22	393.15	2678.50	20.57	14.93	2714.00	3107.16
5	6.4	2.2	2.60	8.76	493.55	5.09	498.64	2435.00	20.61	14.25	2469.86	2968.50
6	4.8	2.2	2.60	5.62	316.58	5.09	321.67	2435.00	15.41	14.25	2464.66	2786.33
7	3.2	1.8	2.60	8.76	493.55	5.09	498.64	2191.50	16.00	14.00	2221.50	2720.14
8	5.6	2.2	2.60	8.11	456.58	5.09	461.67	2191.50	15.81	14.25	2221.56	2683.24
9	6	2.2	2.60	8.11	456.58	5.09	461.67	2191.50	15.81	14.25	2221.56	2683.24
10	3.2	2.2	2.60	4.82	271.35	5.09	276.44	2435.00	17.23	14.25	2466.48	2742.93
11	4	2.2	2.60	5.62	316.58	5.09	321.67	2922.00	15.50	14.25	2951.75	3273.42
12	4	2.2	2.60	5.62	316.58	5.09	321.67	2922.00	16.83	14.25	2953.08	3274.75
13	3.2	2.2	3.17	10.08	567.56	6.22	573.78	2435.00	40.17	14.93	2490.10	3063.88
14	4	1.8	2.60	5.62	316.58	5.09	321.67	2435.00	18.03	14.25	2467.28	2788.95
15	5.6	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	15.81	14.25	2465.06	2926.74
16	4	2.2	2.60	5.62	316.58	5.09	321.67	2435.00	15.41	14.25	2464.66	2786.33
17	4.8	2.2	2.60	8.66	487.65	5.09	492.74	2435.00	32.87	14.25	2482.12	2974.86
18	6	1.8	2.60	8.94	503.38	5.09	508.47	2435.00	17.14	14.25	2466.39	2974.87
19	5.6	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	16.66	14.25	2465.91	2927.59
20	3.2	2.2	2.60	10.64	599.34	5.09	604.43	2435.00	18.20	14.25	2467.45	3071.88
21	2.2	2.2	2.60	6.84	385.40	5.09	390.49	2435.00	15.81	14.25	2465.06	2855.55
22	6	2.2	2.60	5.62	316.58	5.09	321.67	2435.00	13.99	14.25	2463.24	2784.91
23	3.2	2.2	2.60	6.50	366.13	5.09	371.22	2435.00	16.30	14.25	2465.55	2836.77

24	4	2.2	2.60	8.87	499.45	5.09	504.54	2435.00	17.14	14.25	2466.39	2970.93
25	4.8	2.2	2.60	5.62	316.58	5.09	321.67	2435.00	15.41	14.25	2464.66	2786.33
26	6.8	2.2	2.60	5.62	316.58	5.09	321.67	2922.00	16.83	14.25	2953.08	3274.75
27	4	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	15.90	14.25	2465.15	2926.82
28	5.8	2.2	2.60	9.64	542.90	5.09	548.00	2435.00	20.61	14.25	2469.86	3017.85
29	8.8	2.2	2.60	9.64	542.90	5.09	548.00	2435.00	21.76	14.25	2471.01	3019.01
30	8.8	2.2	2.60	8.56	481.75	5.09	486.84	2435.00	16.66	14.25	2465.91	2952.76
31	7.2	2.2	2.60	8.01	451.00	5.09	456.09	2678.50	32.87	14.25	2725.62	3181.71
32	2.8	2.2	2.60	8.76	493.55	5.09	498.64	2191.50	0.00	14.25	2205.75	2704.39
33	6	2.2	2.60	5.13	289.05	5.09	294.14	2435.00	0.00	14.25	2449.25	2743.39
34	4	2.2	2.60	8.76	493.55	5.09	498.64	2435.00	0.00	14.25	2449.25	2947.89
35	4	2.2	2.60	6.84	385.40	5.09	390.49	2435.00	0.00	14.25	2449.25	2839.74
36	4	2.2	2.60	7.70	433.58	5.09	438.67	2435.00	16.66	14.25	2465.91	2904.58
37	4	2.2	2.60	8.70	489.97	5.09	495.06	2435.00	16.66	14.25	2465.91	2960.97
Farmers sowing wheat by broadcasting mehod												
38	3.6	0	2.60	0.00	0.00	5.09	5.09	2191.50	0.00	0.00	2191.50	2196.59
39	1	0	2.60	0.00	0.00	5.09	5.09	2191.50	0.00	0.00	2191.50	2196.59
40	3.2	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
41	3.6	0	2.60	0.00	0.00	5.09	5.09	1948.00	0.00	0.00	1948.00	1953.09
42	6.4	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
43	6	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
44	4	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
45	7.6	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
46	3	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
47	4	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
48	6	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
			2.62	5.95	334.93	5.14	340.06	2440.07	12.85	11.01	2463.93	2804.00

Table E 3.3 Consumption of Direct and Indirect Energy Sources in Sowing operation by Semi-Medium Farmers

Farmer No.	Area for Wheat (ha)	Rated width of drill (m)	Man Hours (h/ha)	Fuel consumption RHP Basis (l/ha)	Direct Energy MJ/ha			Indirect Energy (MJ/ha)				Total Energy (MJ/ha)
					Fuel	Human	Total	Seed	Tractor	Machinery	Total	
Farmers using seed cum ferti drill												
1	2.4	2.2	2.60	5.62	316.58	5.09	321.67	2435.00	16.83	14.25	2466.08	2787.75
2	1.4	2.2	2.60	8.11	456.58	5.09	461.67	2678.50	15.41	14.25	2708.16	3169.84
3	2.8	2.2	2.60	9.37	527.61	5.09	532.70	2435.00	32.87	14.25	2482.12	3014.81
4	2.4	2.2	2.60	5.74	323.46	5.09	328.55	2435.00	20.61	14.25	2469.86	2798.41
5	2.4	2.2	2.60	8.76	493.55	5.09	498.64	2435.00	20.43	14.25	2469.68	2968.32
6	2.4	2.6	2.20	9.08	511.13	4.31	515.43	2678.50	0.00	13.78	2692.28	3207.71
7	4	2.2	2.60	8.11	456.58	5.09	461.67	2678.50	0.00	14.25	2692.75	3154.42
8	2.8	2.2	3.60	8.11	456.58	5.09	461.67	2435.00	0.00	0.00	2435.00	2896.67
9	2.4	1.8	3.17	7.02	395.34	6.22	401.56	2435.00	0.00	14.93	2449.93	2851.49
10	2	2.2	2.60	6.40	360.43	5.09	365.52	2435.00	0.00	14.25	2449.25	2814.77
11	2.4	1.8	3.17	6.87	386.93	6.22	393.15	2435.00	17.10	14.93	2467.03	2860.18
12	2.8	1.8	3.17	9.91	558.05	6.22	564.27	2435.00	17.10	14.93	2467.03	3031.30
13	3	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	17.14	14.25	2466.39	2928.07
14	1.6	2.2	2.60	4.92	277.25	5.09	282.34	2922.00	15.99	14.25	2952.24	3234.58
15	2.4	2.2	2.60	8.21	462.09	5.09	467.18	2922.00	16.88	14.25	2953.13	3420.31
16	0.8	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	0.00	14.25	2449.25	2910.92
17	2.4	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	0.00	14.25	2449.25	2910.92
18	2	2.2	2.60	5.62	316.58	5.09	321.67	2435.00	16.66	14.25	2465.91	2787.59
19	2.8	2.2	2.60	10.52	592.26	5.09	597.35	2435.00	15.50	14.25	2464.75	3062.10
20	0.8	2.2	2.60	6.87	386.97	5.09	392.07	2435.00	18.20	14.25	2467.45	2859.52
21	4	2.2	2.60	7.01	394.84	5.09	399.93	2435.00	16.26	14.25	2465.51	2865.44
22	4	2.2	2.60	6.87	386.97	5.09	392.07	2435.00	16.30	14.25	2465.55	2857.62
23	2.8	2.2	2.60	8.65	487.02	5.09	492.11	2678.50	16.83	14.25	2709.58	3201.70

24	3.2	2.2	2.60	5.62	316.58	5.09	321.67	2678.50	0.00	14.25	2692.75	3014.42
25	2	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	15.41	14.25	2464.66	2926.34
26	2.4	2.2	3.17	6.87	386.93	6.22	393.15	2435.00	0.00	14.93	2449.93	2843.08
27	1.6	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	15.41	14.25	2464.66	2926.34
28	2.8	2.2	2.60	7.73	456.58	5.09	461.67	2922.00	17.23	14.25	2922.00	3383.67
29	0.4	2.2	2.60	6.56	369.67	5.09	374.76	2435.00	15.90	14.25	2465.15	2839.91
30	2.8	2.2	2.60	8.11	456.58	5.09	461.67	2922.00	0.00	14.25	2936.25	3397.92
31	3.6	2.2	2.60	5.62	316.58	5.09	321.67	2191.50	17.14	14.25	2222.89	2544.56
32	3.2	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	16.83	14.25	2466.08	2927.76
33	2.4	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	15.81	14.25	2465.06	2926.74
34	4	2.6	2.20	6.52	366.87	4.31	371.18	2678.50	13.38	13.78	2705.66	3076.84
35	2.8	2.2	2.60	9.45	532.09	5.09	537.18	2435.00	15.81	14.25	2465.06	3002.24
36	4	2.6	2.60	7.73	435.35	5.09	440.44	2435.00	17.23	14.25	2466.48	2906.92
Farmers sowing wheat by broadcasting mehod												
37	2.2	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
38	2.4	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
39	2.8	0	2.60	0.00	0.00	5.09	5.09	2191.50	0.00	0.00	2191.50	2196.59
40	4	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
41	3.4	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
42	2.4	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
43	1.2	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
44	2.4	0	2.60	0.00	0.00	5.09	5.09	2678.50	0.00	0.00	2678.50	2683.59
45	2.6	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
46	2	0	2.60	0.00	0.00	5.09	5.09	1948.00	0.00	0.00	1978.42	1983.51
47	3.2	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
48	2.4	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
49	2.8	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
Average			2.65	5.57	313.88	5.15	319.03	2519.48	9.19	10.21	2538.86	2857.89

Table E 3.4 Consumption of Direct and Indirect Energy Sources in Sowing operation by Small Farmers

Farmer No.	Area for Wheat (ha)	Rated width of drill (m)	Man Hours (h/ha)	Fuel consumption RHP Basis (l/ha)	Direct Energy MJ/ha			Indirect Energy (MJ/ha)				Total Energy (MJ/ha)
					Fuel	Human	Total	Seed	Tractor	Machinery	Total	
Farmers sowing by broadcasting method												
1	1.4	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
2	1.2	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
3	1.2	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
4	0.6	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
5	1.2	0	2.60	0.00	0.00	5.09	5.09	2435.00	0.00	0.00	2435.00	2440.09
6	1.4	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
7	1.4	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
8	1.1	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
9	1.3	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
10	1.7	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
11	1.2	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
12	1.2	0	2.60	0.00	0.00	5.09	5.09	2922.00	0.00	0.00	2922.00	2927.09
Farmers sowing by seed cum ferti drill												
13	2	2.2	2.60	5.61	315.92	5.09	321.01	2435.00	16.83	14.25	2466.08	2787.10
14	1.2	2.2	2.60	5.61	315.92	5.09	321.01	2922.00	0.00	14.25	2936.25	3257.26
15	1.6	2.2	2.60	5.62	316.58	5.09	321.67	2435.00	15.90	14.25	2465.15	2786.82
16	1.7	2.2	2.60	5.61	315.92	5.09	321.01	2435.00	16.83	14.25	2466.08	2787.10
17	1.2	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	0.00	14.25	2449.25	2910.92
18	1.6	2.2	2.60	5.78	325.62	5.09	330.72	2435.00	15.99	14.25	2465.24	2795.96
19	1.2	2.2	2.60	5.71	321.77	5.09	326.86	2435.00	16.17	14.25	2465.42	2792.28
20	1.2	2.2	2.60	8.11	456.58	5.09	461.67	2922.00	0.00	14.25	2936.25	3397.92
21	1.6	2.2	2.60	8.18	460.72	5.09	465.81	2922.00	17.14	14.25	2953.39	3419.20

22	1.6	2.2	2.60	5.62	316.58	5.09	321.67	2191.50	0.00	14.25	2205.75	2527.42
23	2	2.2	2.60	5.58	314.46	5.09	319.55	2435.00	16.83	14.25	2466.08	2785.63
24	1.2	2.2	2.60	5.58	314.46	5.09	319.55	2435.00	0.00	14.25	2449.25	2768.80
25	1.3	2.2	2.60	5.58	314.46	5.09	319.55	2678.50	0.00	14.25	2692.75	3012.30
26	1.2	2.2	2.60	5.58	314.46	5.09	319.55	2435.00	0.00	14.25	2449.25	2768.80
27	1.4	2.2	2.60	5.62	316.58	5.09	321.67	2191.50	0.00	14.25	2205.75	2527.42
28	2	2.2	2.60	5.58	314.46	5.09	319.55	2435.00	0.00	14.25	2449.25	2768.80
29	1.4	2.2	2.60	5.62	316.58	5.09	321.67	2922.00	0.00	14.25	2936.25	3257.92
30	1	2.2	2.60	5.58	314.46	5.09	319.55	2435.00	13.99	14.25	2463.24	2782.79
31	0	2.2	2.60	5.58	314.46	5.09	319.55	2191.50	0.00	14.25	2205.75	2525.30
32	0	2.2	2.60	5.58	314.46	5.09	319.55	2191.50	0.00	14.25	2205.75	2525.30
33	0.2	2.2	2.60	5.58	314.46	5.09	319.55	2435.00	0.00	14.25	2449.25	2768.80
34	0	1.8	3.17	9.91	558.05	6.22	564.27	2435.00	0.00	14.93	2449.93	3014.20
35	2	2.2	2.60	8.05	453.41	5.09	458.50	2435.00	32.87	14.25	2482.12	2940.61
36	2	2.2	2.60	8.05	453.41	5.09	458.50	2678.50	0.00	14.25	2692.75	3151.25
37	1.2	2.2	2.60	8.05	453.41	5.09	458.50	2678.50	0.00	14.25	2692.75	3151.25
38	1.8	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	17.14	14.25	2466.39	2928.07
39	1.6	2.2	2.60	8.09	455.60	5.09	460.69	2435.00	0.00	14.25	2449.25	2909.94
40	1.6	2.2	2.60	8.09	455.60	5.09	460.69	2435.00	0.00	14.25	2449.25	2909.94
41	1.6	2.2	2.60	8.09	455.60	5.09	460.69	2435.00	0.00	14.25	2449.25	2909.94
42	1.6	2.2	2.60	8.09	455.60	5.09	460.69	2435.00	0.00	14.25	2449.25	2909.94
Average			2.60	6.37	358.57	5.10	363.67	2514.28	4.66	12.60	2531.54	2895.20

Table E 3.5 Consumption of Direct and Indirect Energy Sources in Sowing operation by Marginal Farmers

Farmer No.	Area for Wheat (ha)	Rated width of drill	Man Hours (h/ha)	Fuel consumption RHP Basis	Direct Energy MJ/ha			Indirect Energy (MJ/ha)				Total Energy (MJ/ha)
		(m)		(l/ha)	Fuel	Human	Total	Seed	Tractor	Machinery	Total	
Farmers sowing by broadcasting method												
1	0.4	0	2.60	0	0	5.09	5.09	2922.00	0	0	2922.00	2927.09
2	0.8	0	2.60	0	0	5.09	5.09	2922.00	0	0	2922.00	2927.09
3	0.8	0	2.60	0	0	5.09	5.09	2922.00	0	0	2922.00	2927.09
4	0.2	0	2.60	0	0	5.09	5.09	2922.00	0	0	2922.00	2927.09
5	1	0	2.60	0	0	5.09	5.09	2191.50	0	0	2191.50	2196.59
6	1	0	2.60	0	0	5.09	5.09	2922.00	0	0	2922.00	2927.09
7	0.4	0	2.60	0	0	5.09	5.09	2922.00	0	0	2922.00	2927.09
8	0.6	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
9	0.4	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
10	0.8	0	2.60	0	0	5.09	5.09	2678.50	0	0	2678.50	2683.59
11	0.6	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
12	0.2	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
13	0.4	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
14	0.8	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
15	0.3	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
16	0.8	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
17	0.4	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
18	0.8	0	2.60	0	0	5.09	5.09	2678.50	0	0	2678.50	2683.59
19	1	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
20	1	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
21	1	0	2.60	0	0	5.09	5.09	2922.00	0	0	2922.00	2927.09

22	0.4	0	2.60	0	0	5.09	5.09	2922.00	0	0	2922.00	2927.09
23	0.2	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
24	0.3	0	2.60	0	0	5.09	5.09	2191.50	0	0	2191.50	2196.59
25	0.8	0	2.60	0	0	5.09	5.09	2191.50	0	0	2191.50	2196.59
26	0.2	0	2.60	0	0	5.09	5.09	2191.50	0	0	2191.50	2196.59
27	0.4	0	2.60	0	0	5.09	5.09	2678.50	0	0	2678.50	2683.59
28	1	0	2.60	0	0	5.09	5.09	2678.50	0	0	2678.50	2683.59
29	0.6	0	2.60	0	0	5.09	5.09	2678.50	0	0	2678.50	2683.59
30	0.8	0	2.60	0	0	5.09	5.09	2678.50	0	0	2678.50	2683.59
31	0.4	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
32	0.9	0	2.60	0	0	5.09	5.09	2435.00	0	0	2435.00	2440.09
33	0.8	0	2.60	0	0	5.09	5.09	2191.50	0	0	2191.50	2196.59
Sowing by seed drill												
34	0.7	2.2	2.60	8.11	456.58	5.09	461.67	2922.00	17.25	14.00	2953.25	3414.92
35	0.8	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	15.55	14.00	2464.55	2926.22
36	0.4	2.2	2.60	5.62	316.58	5.09	321.67	2922.00	16.83	14.25	2953.08	3274.75
37	1	2.2	2.60	5.62	316.58	5.09	321.67	2435.00	16.83	14.25	2466.08	2787.75
38	0.6	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	15.41	0.00	2450.41	2912.08
39	0.3	2.2	2.60	5.62	316.58	5.09	321.67	2191.50	16.74	14.25	2222.49	2544.17
40	0.8	2.2	2.60	8.11	456.58	5.09	461.67	2922.00	17.25	14.00	2953.25	3414.92
41	0.6	2.2	2.60	8.11	456.58	5.09	461.67	2435.00	15.55	14.00	2464.55	2926.22
Average			2.60	1.00	56.57	5.09	61.66	2577.54	2.41	1.73	2581.67	2643.33

Table E 4.1 Consumption of Direct and Indirect Energy Sources in Irrigation by Large Farmers

Farmer No	Area for wheat ha	Man hours h/ha	Fuel l/ha	Electricity MJ/ha	Direct Energy				Indirect Energy MJ/ha	Total Energy MJ/ha
					Fuel Energy	Electricity	Human	Total		
					MJ/ha	MJ/ha	MJ/ha	MJ/ha		
Farmers Irrigating the field by electric motor pump sets										
1	12	60.88	0	4905	0	4905	119.3	5024.32	18.41	5042.74
2	24	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
3	40	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
4	10	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
5	10	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
6	2.4	30.44	0	4905	0	4905	59.7	4964.66	10.52	4975.18
7	7.2	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
8	12	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
9	6	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
10	16	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
11	15.2	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
12	10	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
13	6	18.26	0	7357.5	0	7357.5	35.8	7393.29	6.31	7399.61
14	3.2	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
15	20	24.35	0	4905	0	4905	47.7	4952.73	9.47	4962.20
16	66	20.70	0	8338.5	0	8338.5	40.6	8379.07	7.15	8386.22
17	15.2	20.70	0	8338.5	0	8338.5	40.6	8379.07	7.15	8386.22
18	14	36.53	0	4905	0	4905	71.6	4976.59	7.15	4983.75
19	12.8	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
20	20	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
21	14	24.35	0	9810	0	9810	47.7	9857.73	9.47	9867.20
22	10	24.35	0	4905	0	4905	47.7	4952.73	8.42	4961.15

23	60	36.53	0	9810	0	9810	71.6	9881.59	14.20	9895.80
24	12	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
25	9.2	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
26	16	48.70	0	4905	0	4905	95.5	5000.46	16.83	5017.29
27	16.8	48.70	0	4905	0	4905	95.5	5000.46	16.83	5017.29
28	18	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
29	14.8	48.70	0	4905	0	4905	95.5	5000.46	16.83	5017.29
30	16	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
31	20	31.05	0	4169.25	0	4169.25	60.9	4230.10	12.07	4242.18
32	19.2	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
33	24	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
34	28	36.53	0	4905	0	4905	71.6	4976.59	12.62	4989.22
Farmers irrigating the field by canal/rever										
35	28.8	40.00	0	0	0	0	78.4	78.4	0.00	78.40
36	12	40.00	0	0	0	0	78.4	78.4	0.00	78.40
37	16	40.00	0	0	0	0	78.4	78.4	0.00	78.40
38	20	30.00	0	0	0	0	58.8	58.8	0.00	58.80
39	10	30.00	0	0	0	0	58.8	58.8	0.00	58.80
40	10.4	30.00	0	0	0	0	58.8	58.8	0.00	58.80
41	10	36.53	0	0	0	0	71.6	71.59	0.00	71.60
42	9.2	30.00	0	0	0	0	58.8	58.8	0.00	58.80
43	5.2	30.00	0	0	0	0	58.8	58.8	0.00	58.80
44	24	30.00	0	0	0	0	58.8	58.8	0.00	58.80
45	8	36.53	0	0	0	0	71.6	71.59	0.00	71.60
Average		35.06	0.00	4114.75	0.00	4114.75	68.73	4183.48	9.18	4192.66

Table E 4.2 Consumption of Direct and Indirect Energy Sources in Irrigation by Medium Farmers

Farmer No.	Area for wheat	Man hours	Fuel	Electricity	Direct Energy				Indirect Energy	Total Energy
					Fuel Energy	Electricity	Human	Total		
	ha	h/ha	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	
Farmers Irrigating the field by electric motor pump sets										
1	3.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
2	4.8	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
3	6.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
4	4.8	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
5	3.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
6	1	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
7	5.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
8	2.8	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
9	6	31.66	0	3188.25	0	3188.25	62.05	3250.30	12.31	3262.61
10	4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
11	3.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
12	4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
13	3.2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
14	4	60.88	0	4905	0	4905	119.33	5024.33	18.41	5042.74
15	6.4	29.68	0	7970.625	0	7970.625	58.17	8028.80	11.54	8040.34
16	6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
17	5.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
18	3.2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
19	2.2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
20	6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
21	3.2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
22	6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22

23	6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
24	4	36.53	0	7357.5	0	7357.5	71.60	7429.10	14.20	7443.30
25	4	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
26	4.5	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
27	4.8	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
28	4.9	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
29	5.8	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
30	8.8	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
31	8.8	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
32	4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
Farmers irrigating the field by canal/rever										
33	4	31.05	0	0	0	0	60.86	60.86	0.00	60.86
34	4.8	31.96	0	0	0	0	62.65	62.65	0.00	62.65
35	7.2	48.70	0	0	0	0	95.46	95.46	0.00	95.46
36	4	36.53	0	0	0	0	71.60	71.60	0.00	71.60
37	6.8	30.00	0	0	0	0	58.80	58.80	0.00	58.80
38	7.6	30.00	0	0	0	0	58.80	58.80	0.00	58.80
39	6	48.70	0	0	0	0	95.46	95.46	0.00	95.46
40	4.8	36.53	0	0	0	0	71.60	71.60	0.00	71.60
41	4	48.70	0	0	0	0	95.46	95.46	0.00	95.46
42	5.6	34.79	0	0	0	0	68.19	68.19	0.00	68.19
43	3.2	36.53	0	0	0	0	71.60	71.60	0.00	71.60
44	3.2	36.53	0	0	0	0	71.60	71.60	0.00	71.60
45	7	29.68	0	0	0	0	58.17	58.17	0.00	58.17
46	4	30.00	0	0	0	0	58.80	58.80	0.00	58.80
47	3.2	30.00	0	0	0	0	58.80	58.80	0.00	58.80
Average		38.18	0.00	3420.45	0.00	3420.45	74.83	3495.28	9.26	3504.54

Table E 4.3 Consumption of Direct and Indirect Energy Sources in Irrigation by Semi Medium Farmers

Farmer No	Area for wheat ha	Man hours h/ha	Fuel l/ha	Electricity MJ/ha	Direct Energy				Indirect Energy MJ/ha	Total Energy MJ/ha
					Fuel Energy	Electricity	Human	Total		
					MJ/ha	MJ/ha	MJ/ha	MJ/ha		
Farmers Irrigating the field by electric motor pump sets										
1	1.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
2	2.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
3	2.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
4	4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
5	2.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
6	2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
7	2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
8	1.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
9	2.6	60.88	0	4905	0	4905	119.33	5024.33	18.41	5042.74
10	2.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
11	4	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
12	4	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
13	2.3	48.70	0	4905	0	4905	95.46	5000.46	0.00	5000.46
14	2.4	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
15	3.2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
16	2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
17	1.2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
18	1.6	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
19	4	48.70	0	4905	0	4905	95.46	5000.46	0.00	5000.46
20	2.4	36.53	0	4905	0	4905	71.60	4976.60	0.00	4976.60
21	4	36.53	0	4905	0	4905	71.60	4976.60	0.00	4976.60
22	1.4	36.53	0	4905	0	4905	71.60	4976.60	0.00	4976.60
Farmers irrigating the field by canal/rever										
23	2.8	33.21	0	0	0	0	65.09	65.09	0.00	65.09
24	2.4	36.53	0	0	0	0	71.60	71.60	0.00	71.60
25	2.8	36.53	0	0	0	0	71.60	71.60	12.62	84.22

26	2.4	36.53	0	0	0	0	71.60	71.60	12.62	84.22
27	2.4	36.53	0	0	0	0	71.60	71.60	12.62	84.22
28	2.8	40.00	0	0	0	0	78.40	78.40	15.55	93.95
29	3.2	48.70	0	0	0	0	95.46	95.46	0.00	95.46
30	2.4	36.53	0	0	0	0	71.60	71.60	12.62	84.22
31	2.4	30.00	0	0	0	0	58.80	58.80	0.00	58.80
32	2	30.00	0	0	0	0	58.80	58.80	0.00	58.80
33	0.8	36.53	0	0	0	0	71.60	71.60	12.62	84.22
34	2.4	30.00	0	0	0	0	58.80	58.80	11.66	70.46
35	3.4	48.70	0	0	0	0	95.46	95.46	16.83	112.29
36	2.4	48.70	0	0	0	0	95.46	95.46	16.83	112.29
37	0.4	30.00	0	0	0	0	58.80	58.80	0.00	58.80
38	2.8	36.53	0	0	0	0	71.60	71.60	12.62	84.22
39	3.6	30.00	0	0	0	0	58.80	58.80	10.37	69.17
40	3.2	30.00	0	0	0	0	58.80	58.80	10.37	69.17
41	4	30.00	0	0	0	0	58.80	58.80	0.00	58.80
42	2.5	30.00	0	0	0	0	58.80	58.80	0.00	58.80
43	2.8	30.00	0	0	0	0	58.80	58.80	0.00	58.80
44	2.2	30.00	0	0	0	0	58.80	58.80	0.00	58.80
45	2.4	30.00	0	0	0	0	58.80	58.80	0.00	58.80
Farmers using Diesel Engine										
46	2.8	29.68	56.41	0	3176.78	0	58.17	3234.95	56.64	3291.60
47	2.7	48.70	57.86	0	3258.24	0	95.46	3353.70	90.61	3444.32
48	2.8	31.05	73.77	0	4154.25	0	60.86	4215.11	75.39	4290.51
49	0.8	31.31	52.07	0	2932.41	0	61.37	2993.78	59.75	3053.54
Average		37.69	4.90	2202.24	275.95	2202.24	73.87	2552.07	13.81	2565.89

Table E 4.4 Consumption of Direct and Indirect Energy Sources in Irrigation by Small Farmers

Farmer No	Area for wheat	Man hours	Fuel	Electricity	Direct Energy				Indirect Energy	Total Energy
					Fuel Energy	Electricity	Human	Total		
	ha	h/ha	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	
Farmers Irrigating the field by electric motor pump sets										
1	1.2	29.68	0	7970.625	0	7970.625	58.17	8028.80	10.26	8039.05
2	1.2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
3	1.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
4	1.4	31.96	0	4291.875	0	4291.875	62.65	4354.52	0.00	4354.52
5	1.2	48.70	0	4905	0	4905	95.46	5000.46	0.00	5000.46
6	1.3	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
7	1.2	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
8	1.4	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
9	1	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
10	2	48.70	0	4905	0	4905	95.46	5000.46	16.83	5017.29
11	1.2	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
12	1.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
13	1.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
14	1.5	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
Farmers irrigating the field by canal/rever										
15	0.6	30.00	0	0	0	0	58.80	58.8	0.00	58.80
16	1.2	30.00	0	0	0	0	58.80	58.8	0.00	58.80
17	2	36.53	0	0	0	0	71.60	71.59	0.00	71.60
18	1	48.70	0	0	0	0	95.46	95.46	16.83	112.29
19	1.2	48.70	0	0	0	0	95.46	95.46	0.00	95.46
20	1.2	30.00	0	0	0	0	58.80	58.8	57.25	116.05
21	1.6	30.00	0	0	0	0	58.80	58.8	57.25	116.05

22	1.2	30.00	0	0	0	0	58.80	58.8	57.25	116.05
23	1.2	30.00	0	0	0	0	58.80	58.8	55.81	114.61
24	1.6	30.00	0	0	0	0	58.80	58.8	55.81	114.61
25	1.2	48.70	0	0	0	0	95.46	95.46	0.00	95.46
26	0	48.70	0	0	0	0	95.46	95.46	0.00	95.46
27	0	48.70	0	0	0	0	95.46	95.46	0.00	95.46
28	0.2	48.70	0	0	0	0	95.46	95.46	0.00	95.46
29	0	48.70	0	0	0	0	95.46	95.46	0.00	95.46
30	2	30.00	0	0	0	0	58.80	58.8	55.81	114.61
31	1.8	36.53	0	0	0	0	71.60	71.59	12.62	84.22
32	1.6	30.00	0	0	0	0	58.80	58.8	0.00	58.80
Farmers using Diesel Engine										
33	0.6	41.40	98.37	0.00	5539.01	0.00	81.14	5620.15	100.52	5720.68
34	1.6	39.57	75.22	0.00	4235.71	0.00	77.56	4313.28	75.52	4388.79
35	2	42.62	81.01	0.00	4561.54	0.00	83.53	4645.07	81.33	4726.39
36	1.6	29.68	56.42	0.00	3176.79	0.00	58.17	3234.96	56.64	3291.60
37	1.7	36.53	43.40	0.00	2443.68	0.00	71.60	2515.28	67.96	2583.24
38	1.6	28.10	43.40	0.00	2443.68	0.00	55.07	2498.75	52.28	2551.03
39	2	36.53	43.40	0.00	2443.68	0.00	71.60	2515.28	67.96	2583.24
40	2	40.59	57.86	0.00	3258.24	0.00	79.55	3337.79	75.51	3413.30
41	1.4	42.62	81.01	0.00	4561.54	0.00	83.53	4645.07	81.33	4726.39
42	1.6	33.92	56.42	0.00	3176.79	0.00	66.48	3243.27	64.73	3308.00
Average		38.77	15.15	1693.39	853.35	1693.39	76.00	2622.74	30.06	2652.80

Table E 4.5 Consumption of Direct and Indirect Energy Sources in Irrigation by marginal Farmers

Farmer No.	Area for wheat	Man hours	Fuel	Electricity	Direct Energy				Indirect Energy	Total Energy
					Fuel Energy	Electricity	Human	Total		
	ha	h/ha	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha
Farmers Irrigating the field by electric motor pump sets										
1	0.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
2	0.8	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
3	0.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
4	0.8	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
5	0.3	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
6	0.8	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
7	1	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
8	1	60.88	0	4905	0	4905	119.33	5024.33	18.41	5042.74
9	0.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
10	0.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
11	0.6	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
12	1	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
13	0.4	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
14	1	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
15	0.8	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
16	1	36.53	0	4905	0	4905	71.60	4976.60	12.62	4989.22
Farmers irrigating the field by canal/rever										
17	0.8	30.00	0	0	0	0	58.80	58.8	0.00	58.80
18	0.8	30.00	0	0	0	0	58.80	58.8	0.00	58.80
19	0.2	30.00	0	0	0	0	58.80	58.8	0.00	58.80

20	0.8	30.00	0	0	0	0	58.80	58.8	0.00	58.80
21	0.4	30.00	0	0	0	0	58.80	58.8	0.00	58.80
22	0.8	36.53	0	0	0	0	71.60	71.59	0.00	71.60
23	0.4	36.53	0	0	0	0	71.60	71.59	12.62	84.22
24	0.2	36.53	0	0	0	0	71.60	71.59	67.96	139.56
25	0.3	36.53	0	0	0	0	71.60	71.59	0.00	71.60
26	0.3	36.53	0	0	0	0	71.60	71.59	67.96	139.56
27	0.2	36.53	0	0	0	0	71.60	71.59	0.00	71.60
28	0.8	30.00	0	0	0	0	58.80	58.8	0.00	58.80
29	0.4	30.00	0	0	0	0	58.80	58.8	0.00	58.80
30	0.6	30.00	0	0	0	0	58.80	58.8	0.00	58.80
31	0.8	30.00	0	0	0	0	58.80	58.8	0.00	58.80
Farmer using diesel engine										
32	1	36.53	43.40	0.00	2443.68	0	71.60	2515.27	67.96	2583.24
33	0.4	42.62	81.01	0.00	4561.54	0	83.53	4645.06	81.33	4726.39
34	0.4	36.53	43.40	0.00	2443.68	0	71.60	2515.27	67.96	2583.24
35	0.4	48.70	57.86	0.00	3258.24	0	95.46	3353.70	90.61	3444.32
36	0.3	36.53	43.40	0.00	2443.68	0	71.60	2515.27	67.96	2583.24
37	0.2	29.68	56.42	0.00	3176.79	0	58.17	3234.95	56.64	3291.60
38	0.6	36.53	43.40	0.00	2443.68	0	71.60	2515.27	67.96	2583.24
39	1	36.53	43.40	0.00	2443.68	0	71.60	2515.27	67.96	2583.24
40	0.6	29.22	69.44	0.00	3909.89	0	57.28	3967.16	70.96	4038.12
41	0.9	32.88	78.11	0.00	4398.63	0	64.44	4463.06	79.83	4542.89
Average		35.70	13.65	1914.15	768.87	1914.15	69.98	2752.98	26.23	2779.22

Table E.5.1 Consumption of Direct and Indirect Energy Sources in Fertilizer Application by Large Farmers

Farmer No	Area Under Wheat	NPK	Urea	Man Hour	Direct Energy	Indirect Energy			Total
					human	NPK	Urea	Total	
	MJ/ha	kg/ha	kg/ha	h/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha
1	12	125	250	1	1.96	1487	6969	8456	8457.96
2	24	125	250	1.5	2.94	1487	6969	8456	8458.94
3	40	125	250	1	1.96	1487	6969	8456	8457.96
4	10	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
5	20	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
6	17.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
7	14	125	375	1	1.96	1487	10453.5	11940.5	11942.46
8	11.2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
9	16	125	375	1	1.96	1487	10453.5	11940.5	11942.46
10	10	125	375	1	1.96	1487	10453.5	11940.5	11942.46
11	16	125	375	1	1.96	1487	10453.5	11940.5	11942.46
12	15.2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
13	22.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
14	10	125	500	1	1.96	1487	13938	15425	15426.96
15	12	125	375	1	1.96	1487	10453.5	11940.5	11942.46
16	12	125	375	1	1.96	1487	10453.5	11940.5	11942.46
17	20	125	375	1	1.96	1487	10453.5	11940.5	11942.46
18	66	125	375	1	1.96	1487	10453.5	11940.5	11942.46
19	28	125	375	1	1.96	1487	10453.5	11940.5	11942.46
20	10	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
21	52.8	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
22	30.4	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
23	12.8	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
24	32	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
25	20	125	375	1	1.96	1487	10453.5	11940.5	11942.46
26	10	125	375	1	1.96	1487	10453.5	11940.5	11942.46
27	72	125	375	1	1.96	1487	10453.5	11940.5	11942.46
28	12	125	250	1	1.96	1487	6969	8456	8457.96
29	11	125	250	1	1.96	1487	6969	8456	8457.96
30	20	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
31	16.8	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
32	32	125	375	1	1.96	1487	10453.5	11940.5	11942.46
33	18	125	500	1.5	2.94	1487	13938	15425	15427.94
34	16	125	500	1.5	2.94	1487	13938	15425	15427.94
35	30.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
36	20	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
37	11.6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
38	24.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
39	28	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
40	32	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
41	18.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
42	16	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
43	22	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
44	24	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
45	12	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
Average					2.26	1487.00	9950.18	11437.18	11439.45

Table E 5.2 Consumption of Direct and Indirect Energy Sources in Fertilizer Application by Medium Farmers

Farmer No	Area Under Wheat	NPK	Urea	Man Hour	Direct Energy	Indirect Energy			Total
	MJ/ha	kg/ha	kg/ha	h/ha	human	NPK	Urea	Total	MJ/ha
					MJ/ha	MJ/ha	MJ/ha	MJ/ha	
1	4.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
2	4.8	125	250	1.5	2.94	1487	6969	8456	8458.94
3	7.27	125	175	1.5	2.94	1487	4878.3	6365.3	6368.24
4	8.08	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
5	6.4	125	250	1.5	2.94	1487	6969	8456	8458.94
6	4.8	125	250	1.5	2.94	1487	6969	8456	8458.94
7	7.2	125	250	1.5	2.94	1487	6969	8456	8458.94
8	4.4	125	250	1.5	2.94	1487	6969	8456	8458.94
9	5.6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
10	9.2	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
11	4.8	125	300	1.5	2.94	1487	8362.8	9849.8	9852.74
12	6	125	300	1.5	2.94	1487	8362.8	9849.8	9852.74
13	8	125	300	1.5	2.94	1487	8362.8	9849.8	9852.74
14	4.8	125	300	1.5	2.94	1487	8362.8	9849.8	9852.74
15	6	125	300	1.5	2.94	1487	8362.8	9849.8	9852.74
16	6	125	500	1.5	2.94	1487	13938	15425	15427.94
17	6	125	500	1.5	2.94	1487	13938	15425	15427.94
18	6	125	500	1.5	2.94	1487	13938	15425	15427.94
19	4.6	125	500	1.5	2.94	1487	13938	15425	15427.94
20	5.6	125	500	1.5	2.94	1487	13938	15425	15427.94
21	4	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
22	4.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
23	7.2	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
24	8	125	312.5	1.5	2.94	1487	8711.25	10198.25	10201.19
25	6	125	250	1.5	2.94	1487	6969	8456	8458.94
26	8	125	250	1.5	2.94	1487	6969	8456	8458.94
27	4.8	125	312.5	1.5	2.94	1487	8711.25	10198.25	10201.19
28	8	125	250	1.5	2.94	1487	6969	8456	8458.94
29	6	125	325	1.5	2.94	1487	9059.7	10546.7	10549.64
30	6	125	500	1.5	2.94	1487	13938	15425	15427.94
31	6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
32	6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
33	6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
34	6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
35	7.6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
36	6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
37	6.8	125	500	1.5	2.94	1487	13938	15425	15427.94
38	8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
39	4	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
40	6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
41	9.2	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
42	10	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
43	7.2	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
44	6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
45	6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
46	4	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
47	4	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
48	4.8	125	250	1.5	2.94	1487	6969	8456	8458.94
Average					2.94	1487	9872.75	11359.75	11362.69

Table E 5.3 Consumption of Direct and Indirect Energy Sources in Fertilizer Application by Semi Medium Farmers

Farmer No	Area Under Wheat	NPK	Urea	Man Hour	Direct Energy	Indirect Energy			Total
	MJ/ha	kg/ha	kg/ha	h/ha	human	NPK	Urea	Total	MJ/ha
					MJ/ha	MJ/ha	MJ/ha	MJ/ha	
1	3.2	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
2	2.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
3	4	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
4	2.4	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
5	2.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
6	4	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
7	2.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
8	2.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
9	2.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
10	3.4	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
11	3.2	125	250	1.5	2.94	1487	6969	8456	8458.94
12	2.8	125	250	1	1.96	1487	6969	8456	8457.96
13	4	125	375	1	1.96	1487	10453.5	11940.5	11942.46
14	3.23	125	375	1	1.96	1487	10453.5	11940.5	11942.46
15	2.02	125	375	1	1.96	1487	10453.5	11940.5	11942.46
16	4	125	250	1	1.96	1487	6969	8456	8457.96
17	2	125	250	1	1.96	1487	6969	8456	8457.96
18	2.4	125	250	1	1.96	1487	6969	8456	8457.96
19	3.2	125	187.5	1	1.96	1487	5226.75	6713.75	6715.71
20	2.4	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
21	2.57	125	325	1	1.96	1487	9059.7	10546.7	10548.66
22	2.8	125	500	1	1.96	1487	13938	15425	15426.96
23	3.2	125	500	1	1.96	1487	13938	15425	15426.96
24	2.8	125	500	1	1.96	1487	13938	15425	15426.96
25	2.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
26	4	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
27	4	125	250	1	1.96	1487	6969	8456	8457.96
28	4.8	125	250	1	1.96	1487	6969	8456	8457.96
29	2.8	125	250	1	1.96	1487	6969	8456	8457.96
30	3.2	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
31	4	125	250	1	1.96	1487	6969	8456	8457.96
32	2.8	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
33	2.4	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
34	4	125	250	1	1.96	1487	6969	8456	8457.96
35	4	125	375	1	1.96	1487	10453.5	11940.5	11942.46
36	2.4	125	375	1	1.96	1487	10453.5	11940.5	11942.46
37	2.8	125	250	1	1.96	1487	6969	8456	8457.96
38	4	125	250	1	1.96	1487	6969	8456	8457.96
39	2.8	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
40	3.6	125	375	1	1.96	1487	10453.5	11940.5	11942.46
41	3.2	125	250	1	1.96	1487	6969	8456	8457.96
42	2.4	125	375	1	1.96	1487	10453.5	11940.5	11942.46
43	4	125	375	1	1.96	1487	10453.5	11940.5	11942.46
44	3	125	375	1	1.96	1487	10453.5	11940.5	11942.46
45	2.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
46	4	125	250	1	1.96	1487	6969	8456	8457.96
47	2.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
48	2.8	125	500	1	1.96	1487	13938	15425	15426.96
49	2.8	125	500	1	1.96	1487	13938	15425	15426.96
Average					2.18	1487.00	9465.04	10952.04	10954.22

Table E 5.5 Consumption of Direct and Indirect Energy Sources in Fertilizer Application by Small Farmers

Farmer No	Area Under Wheat	NPK	Urea	Man Hour	Direct Energy human	Indirect Energy			Total
	MJ/ha	kg/ha	kg/ha	h/ha	MJ/ha	NPK MJ/ha	Urea MJ/ha	Total MJ/ha	MJ/ha
	1	1.2	125	375	1	1.96	1487	10453.5	11940.5
2	1.2	125	250	1	1.96	1487	6969	8456	8457.96
3	1.2	125	250	1	1.96	1487	6969	8456	8457.96
4	1.2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
5	2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
6	1.4	125	312.5	1	1.96	1487	8711.25	10198.25	10200.21
7	2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
8	2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
9	1.6	125	250	1	1.96	1487	6969	8456	8457.96
10	1.21	125	250	1	1.96	1487	6969	8456	8457.96
11	1.61	125	175	1	1.96	1487	4878.3	6365.3	6367.26
12	2	125	175	1	1.96	1487	4878.3	6365.3	6367.26
13	1.21	125	375	1	1.96	1487	10453.5	11940.5	11942.46
14	1.6	125	375	1	1.96	1487	10453.5	11940.5	11942.46
15	1.7	125	250	1	1.96	1487	6969	8456	8457.96
16	1.2	125	250	1	1.96	1487	6969	8456	8457.96
17	1.6	125	187.5	1	1.96	1487	5226.75	6713.75	6715.71
18	1.2	125	187.5	1	1.96	1487	5226.75	6713.75	6715.71
19	1.2	125	187.5	1	1.96	1487	5226.75	6713.75	6715.71
20	1.6	125	187.5	1	1.96	1487	5226.75	6713.75	6715.71
21	1.6	125	187.5	1	1.96	1487	5226.75	6713.75	6715.71
22	2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
23	1.2	125	250	1	1.96	1487	6969	8456	8457.96
24	1.3	125	375	1	1.96	1487	10453.5	11940.5	11942.46
25	1.2	125	325	1	1.96	1487	9059.7	10546.7	10548.66
26	1.6	125	375	1	1.96	1487	10453.5	11940.5	11942.46
27	2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
28	1.4	125	250	1	1.96	1487	6969	8456	8457.96
29	1.2	125	250	1	1.96	1487	6969	8456	8457.96
30	1.2	125	250	1	1.96	1487	6969	8456	8457.96
31	1.8	125	250	1	1.96	1487	6969	8456	8457.96
32	2	125	250	1	1.96	1487	6969	8456	8457.96
33	1.6	125	250	1	1.96	1487	6969	8456	8457.96
34	2	125	250	1	1.96	1487	6969	8456	8457.96
35	2.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
36	2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
37	1.2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
38	1.8	125	500	1	1.96	1487	13938	15425	15426.96
39	1.6	125	375	1	1.96	1487	10453.5	11940.5	11942.46
40	1.6	125	375	1	1.96	1487	10453.5	11940.5	11942.46
41	2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
42	1.6	125	375	1	1.96	1487	10453.5	11940.5	11942.46
43	1.6	125	375	1	1.96	1487	10453.5	11940.5	11942.46
Average					1.96	1487	8460.042	9947.042	9949.002

Table E 5.5 Consumption of Direct and Indirect Energy Sources in Fertilizer Application by Marginal Farmers

Farmer No	Area Under Wheat	NPK	Urea	Man Hour	Direct Energy human	Indirect Energy			Total
	MJ/ha	kg/ha	kg/ha	h/ha	MJ/ha	NPK MJ/ha	Urea MJ/ha	Total MJ/ha	MJ/ha
1	0.4	125	375	1	1.96	1487	10453.5	11940.5	11942.46
2	0.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
3	0.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
4	0.2	125	375	1	1.96	1487	10453.5	11940.5	11942.46
5	0.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
6	1	125	375	1	1.96	1487	10453.5	11940.5	11942.46
7	0.4	125	375	1	1.96	1487	10453.5	11940.5	11942.46
8	0.5	125	250	1	1.96	1487	6969	8456	8457.96
9	0.404	125	175	1	1.96	1487	4878.3	6365.3	6367.26
10	0.808	125	175	1	1.96	1487	4878.3	6365.3	6367.26
11	0.606	125	175	1	1.96	1487	4878.3	6365.3	6367.26
12	0.2	125	250	1	1.96	1487	6969	8456	8457.96
13	0.404	125	250	1	1.96	1487	6969	8456	8457.96
14	0.808	125	250	1	1.96	1487	6969	8456	8457.96
15	0.4	125	250	1	1.96	1487	6969	8456	8457.96
16	0.8	125	250	1	1.96	1487	6969	8456	8457.96
17	0.6	125	250	1	1.96	1487	6969	8456	8457.96
18	0.404	125	187.5	1	1.96	1487	5226.75	6713.75	6715.71
19	0.8	125	375	1	1.96	1487	10453.5	11940.5	11942.46
20	1	125	250	1	1.96	1487	6969	8456	8457.96
21	1	125	250	1	1.96	1487	6969	8456	8457.96
22	1	125	250	1.5	2.94	1487	6969	8456	8458.94
23	0.8	125	250	1.5	2.94	1487	6969	8456	8458.94
24	0.4	125	250	1.5	2.94	1487	6969	8456	8458.94
25	1	125	250	1.5	2.94	1487	6969	8456	8458.94
26	1	125	250	1.5	2.94	1487	6969	8456	8458.94
27	0.4	125	250	1.5	2.94	1487	6969	8456	8458.94
28	0.4	125	250	1.5	2.94	1487	6969	8456	8458.94
29	0.6	125	250	1.5	2.94	1487	6969	8456	8458.94
30	0.8	125	500	1.5	2.94	1487	13938	15425	15427.94
31	0.8	125	250	1.5	2.94	1487	6969	8456	8458.94
32	0.4	125	250	1.5	2.94	1487	6969	8456	8458.94
33	0.9	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
34	1	125	500	1.5	2.94	1487	13938	15425	15427.94
35	0.4	125	500	1.5	2.94	1487	13938	15425	15427.94
36	0.267	125	500	1.5	2.94	1487	13938	15425	15427.94
37	0.6	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
38	1	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
39	0.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
40	0.8	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
41	1	125	375	1.5	2.94	1487	10453.5	11940.5	11943.44
Average					2.44	1487.00	8643.26	10130.26	10132.70

Table E 6.1 Consumption of Direct and Indirect Energy Sources in Plant Protection Operation by Large Farmers

Farmer Number	Area Under ha	Man-hr h/ha	Fuel Consumption l/ha	Direct Energy			Indirect Energy			Total MJ/ha
				Human Energy	Fuel Energy	Total	Machinery	Chemical	Total	
				MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	
Farmers using SI engine operated knapsack sprayer										
1	24	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
2	20	5.56	2.78	10.89	156.42	167.31	0	491	491	658.31
3	12	5.56	2.78	10.89	156.42	167.31	0	480	480	647.31
4	12.8	5.56	2.78	10.89	156.42	167.31	0	491	491	658.31
5	10	5.56	2.78	10.89	156.42	167.31	0	501	501	668.31
6	10.4	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
7	15.2	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
8	8	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
9	5.2	5.56	2.78	10.89	156.42	167.31	0	491	491	658.31
10	24	5.56	2.78	10.89	156.42	167.31	0	480	480	647.31
11	14	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
Farmers using manual operated knapsack sprayer										
12	12	6.67	0.00	13.07	0	13.07	0	498.00	498.00	511.07
13	9.2	6.67	0.00	13.07	0	13.07	0	432.00	432.00	445.07
14	20	6.67	0.00	13.07	0	13.07	0	477.00	477.00	490.07
15	14.8	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
16	16	6.67	0.00	13.07	0	13.07	0	501.00	501.00	514.07
17	20	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
18	19.2	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
19	9.2	6.67	0.00	13.07	0	13.07	0	477.00	477.00	490.07
20	24	6.67	0.00	13.07	0	13.07	0	498.00	498.00	511.07
21	16	6.67	0.00	13.07	0	13.07	0	485	485	498.07

22	12	6.67	0.00	13.07	0	13.07	0	480	480	493.07
23	16	6.67	0.00	13.07	0	13.07	0	480	480	493.07
24	6	6.67	0.00	13.07	0	13.07	0	501.00	501.00	514.07
Farmers using tractor operated power sprayer										
25	10	21.88	24.61	42.89	1385.97	1474.51	45.65	491.00	536.65	2011.16
26	16	21.88	20.56	42.89	1157.92	1247.61	46.80	480	526.80	1774.40
27	16.8	21.88	20.56	42.89	1157.92	1247.61	46.80	485	531.80	1779.40
28	18	21.88	23.21	42.89	1307.01	1401.01	51.11	501.00	552.11	1953.12
29	20	21.88	25.60	42.89	1441.41	1542.17	57.87	491.00	548.87	2091.04
30	40	21.88	24.29	42.89	1367.64	1458.67	48.14	501.00	549.14	2007.82
31	10	21.88	24.29	42.89	1367.64	1458.67	48.14	485.00	533.14	1991.82
32	10	21.88	22.77	42.89	1282.16	1371.85	46.80	485.00	531.80	1903.64
33	3.2	21.88	22.85	42.89	1286.58	1376.26	46.80	432.00	478.80	1855.06
34	28	21.88	27.07	42.89	1524.57	1625.33	57.87	491.00	548.87	2174.20
35	28.8	21.88	22.77	42.89	1282.16	1371.85	46.80	498.00	544.80	1916.64
36	66	21.88	16.34	42.89	919.93	1006.10	43.28	432.00	475.28	1481.38
37	15.2	21.88	17.23	42.89	970.18	1070.94	57.87	485.00	542.87	1613.81
38	2.4	21.88	25.30	42.89	1424.62	1515.28	47.77	491.00	538.77	2054.05
39	10	21.88	25.79	42.89	1452.23	1543.51	48.39	477.00	525.39	2068.91
40	7.2	21.88	0.00	42.89	0.00	42.89	0.00	498.00	498.00	540.89
41	12	21.88	20.83	42.89	1172.83	1263.86	48.14	432.00	480.14	1744.01
42	6	21.88	26.21	42.89	1475.98	1567.01	48.14	491.00	539.14	2106.15
43	14	21.88	25.79	42.89	1452.23	1543.51	48.39	485.00	533.39	2076.91
44	10	21.88	19.60	42.89	1103.92	1191.21	44.40	485.00	529.40	1720.61
45	60	21.88	27.07	42.89	1524.57	1625.33	57.87	477.00	534.87	2160.20
Average		13.50	10.96	26.45	617.29	665.68	21.93	483.16	505.09	1170.77

Table E 6.2 Consumption of Direct and Indirect Energy Sources in Plant Protection Operation by Medium Farmers

Farmer Number	Area Under	Man-hr	Fuel Consumption	Direct Energy			Indirect Energy			Total
				Human Energy	Fuel Energy	Total	Machinery	Chemical	Total	
	ha	h/ha	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha
Farmers using tractor operated power sprayer										
1	3.4	21.88	17.16	42.89	966.31	1056.47	47.27	485.00	532.27	1541.47
2	7	21.88	15.79	42.89	889.01	979.17	47.27	432.00	479.27	1411.17
3	3.2	21.88	20.83	42.89	1172.83	1273.59	57.87	501.00	558.87	1774.59
4	2.2	21.88	18.67	42.89	1051.35	1138.64	44.40	485	529.4	1623.64
5	4	21.88	24.91	42.89	1402.54	1503.30	57.87	480	537.87	1983.30
6	5.6	21.88	19.60	42.89	1103.92	1191.21	44.40	485.00	529.4	1676.21
7	6	21.88	15.79	42.89	889.01	976.30	44.40	485.00	529.4	1461.30
8	7.6	21.88	24.91	42.89	1402.54	1493.57	48.14	491.00	539.14	1984.57
9	4.8	21.88	13.53	42.89	762.01	848.18	43.28	480	523.28	1328.18
10	6	21.88	24.91	42.89	1402.54	1503.30	57.87	477.00	534.87	1980.30
11	4	21.88	24.91	42.89	1402.54	1503.30	57.87	498.00	555.87	2001.30
12	6	21.88	25.30	42.89	1424.62	1515.66	48.14	432.00	480.14	1947.66
13	7.6	21.88	24.91	42.89	1402.54	1503.30	57.87	491.00	548.87	1994.30
14	4	21.88	18.67	42.89	1051.35	1138.89	44.65	501.00	545.65	1639.89
15	5.8	21.88	22.15	42.89	1247.37	1334.66	44.40	485.00	529.4	1819.66
16	3	21.88	24.91	42.89	1402.54	1503.30	57.87	432.00	489.87	1935.30
17	4	21.88	13.53	42.89	762.01	848.18	43.28	485.00	528.28	1333.18
18	5.6	21.88	15.99	42.89	900.60	987.90	44.40	485.00	529.4	1472.90
19	2.8	21.88	24.91	42.89	1402.54	1503.30	57.87	485.00	542.87	1988.30
20	6	21.88	19.60	42.89	1103.92	1191.21	44.40	477.00	521.4	1668.21
21	6.4	21.88	25.60	42.89	1441.41	1542.17	57.87	491.00	548.87	2033.17

Farmers using SI engine operated knapsack sprayer										
22	8.8	5.56	2.78	10.89	156.42	167.31	0	477.00	477.00	644.31
23	7.2	5.56	2.78	10.89	156.42	167.31	0	498.00	498.00	665.31
24	4.8	5.56	2.78	10.89	156.42	167.31	0	480	480	647.31
25	4	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
26	4	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
27	3.2	5.56	2.78	10.89	156.42	167.31	0	498.00	498.00	665.31
Farmers using knapsack sprayer										
28	3.2	6.67	0	13.07	0	13.07	0	432.00	432.00	445.07
29	4	6.67	0	13.07	0	13.07	0	491.00	491.00	504.07
30	3.6	6.67	0	13.07	0	13.07	0	480	480	493.07
31	3.2	6.67	0	13.07	0	13.07	0	491.00	491.00	504.07
32	4	6.67	0	13.07	0	13.07	0	501.00	501.00	514.07
33	4.8	6.67	0	13.07	0	13.07	0	477.00	477.00	490.07
34	3.6	6.67	0	13.07	0	13.07	0	485	485	498.07
35	1	6.67	0	13.07	0	13.07	0	491.00	491.00	504.07
36	4	6.67	0	13.07	0	13.07	0	477.00	477.00	490.07
37	4.8	6.67	0	13.07	0	13.07	0	498.00	498.00	511.07
38	6.4	6.67	0	13.07	0	13.07	0	498.00	498.00	511.07
39	5.6	6.67	0	13.07	0	13.07	0	491.00	491.00	504.07
40	3.2	6.67	0	13.07	0	13.07	0	480	480	493.07
41	6	6.67	0	13.07	0	13.07	0	491.00	491.00	504.07
42	6	6.67	0	13.07	0	13.07	0	501.00	501.00	514.07
43	3.2	6.67	0	13.07	0	13.07	0	485.00	485.00	498.07
44	4	6.67	0	13.07	0	13.07	0	432.00	432.00	445.07
45	6.8	6.67	0	13.07	0	13.07	0	485	485	498.07
46	8.8	6.67	0	13.07	0	13.07	0	485.00	485.00	498.07
47	4	6.67	0	13.07	0	13.07	0	491.00	491.00	504.07
48	4.8	6.67	0	13.07	0	13.07	0	491.00	491.00	504.07
Average		13.19	9.44	25.84	531.71	579.46	21.90	482.06	503.97	1061.52

Table E 6.3 Consumption of Direct and Indirect Energy Sources in Plant Protection Operation by Semi Medium Farmers

Farmer Number	Area Under ha	Man-hr h/ha	Fuel Consumption l/ha	Direct Energy			Indirect Energy			Total MJ/ha
				Human Energy MJ/ha	Fuel Energy MJ/ha	Total MJ/ha	Machinery MJ/ha	Chemical MJ/ha	Total MJ/ha	
Farmers using SI engine operated knapsack sprayer										
1	4	5.56	2.78	10.89	156.42	167.31	0	480	480	647.31
2	2	5.56	2.78	10.89	156.42	167.31	0	491	491	658.31
3	2.8	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
Farmers using knapsack sprayer										
4	1.4	6.67	0	13.07	0	13.07	0	501	501	514.07
5	2.8	6.67	0	13.07	0	13.07	0	485	485	498.07
6	2.4	6.67	0	13.07	0	13.07	0	477	477	490.07
7	2.4	6.67	0	13.07	0	13.07	0	498	498	511.07
8	4	6.67	0	13.07	0	13.07	0	432	432	445.07
9	2.4	6.67	0	13.07	0	13.07	0	491	491	504.07
10	2.4	6.67	0	13.07	0	13.07	0	480	480	493.07
11	2.8	6.67	0	13.07	0	13.07	0	485	485	498.07
12	2.8	6.67	0	13.07	0	13.07	0	491	491	504.07
13	2.4	6.67	0	13.07	0	13.07	0	501	501	514.07
14	2.4	6.67	0	13.07	0	13.07	0	485	485	498.07
15	0	6.67	0	13.07	0	13.07	0	477	477	490.07
16	3.2	6.67	0	13.07	0	13.07	0	498	498	511.07
17	2	6.67	0	13.07	0	13.07	0	432	432	445.07
18	1.6	6.67	0	13.07	0	13.07	0	480	480	493.07
19	2.4	6.67	0	13.07	0	13.07	0	485	485	498.07
20	2.8	6.67	0	13.07	0	13.07	0	491	491	504.07
21	0.8	6.67	0	13.07	0	13.07	0	501	501	514.07
22	2.6	6.67	0	13.07	0	13.07	0	485	485	498.07
23	2.4	6.67	0	13.07	0	13.07	0	485	485	498.07

24	2	6.67	0	13.07	0	13.07	0	477	477	490.07
25	0	6.67	0	13.07	0	13.07	0	498	498	511.07
26	0.8	6.67	0	13.07	0	13.07	0	432	432	445.07
27	4	6.67	0	13.07	0	13.07	0	491	491	504.07
28	0	6.67	0	13.07	0	13.07	0	485	485	498.07
29	2.4	6.67	0	13.07	0	13.07	0	491	491	504.07
30	3.2	6.67	0	13.07	0	13.07	0	501	501	514.07
31	2	6.67	0	13.07	0	13.07	0	485	485	498.07
32	1.2	6.67	0	13.07	0	13.07	0	485	485	498.07
33	2.4	6.67	0	13.07	0	13.07	0	477	477	490.07
34	1.6	6.67	0	13.07	0	13.07	0	498	498	511.07
35	3.4	6.67	0	13.07	0	13.07	0	432	432	445.07
36	2.4	6.67	0	13.07	0	13.07	0	491	491	504.07
37	0.4	6.67	0	13.07	0	13.07	0	480	480	493.07
38	4	6.67	0	13.07	0	13.07	0	485	485	498.07
39	2.8	6.67	0	13.07	0	13.07	0	491	491	504.07
40	3.6	6.67	0	13.07	0	13.07	0	501	501	514.07
41	3.2	6.67	0	13.07	0	13.07	0	485	485	498.07
42	2.4	6.67	0	13.07	0	13.07	0	485	485	498.07
43	4	6.67	0	13.07	0	13.07	0	477	477	490.07
44	0	6.67	0	13.07	0	13.07	0	498	498	511.07
45	2.8	6.67	0	13.07	0	13.07	0	432	432	445.07
46	4	6.67	0	13.07	0	13.07	0	491	491	504.07
47	2.2	6.67	0	13.07	0	13.07	0	480	480	493.07
48	2.4	6.67	0	13.07	0	13.07	0	485	485	498.07
49	1.4	6.67	0	13.07	0	13.07	0	491	491	504.07
Average		6.60	0.17	12.94	9.58	22.51	0.00	482.45	482.45	504.96

Table E 6.4 Consumption of Direct and Indirect Energy Sources in Plant Protection Operation by Small Farmers

Farmer Number	Area Under ha	Man-hr h/ha	Fuel Consumption l/ha	Direct Energy			Indirect Energy			Total MJ/ha
				Human Energy	Fuel Energy	Total	Machinery	Chemical	Total	
				MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	
Farmers using SI engine operated knapsack sprayer										
1	2	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
2	0.2	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
3	1.2	5.56	2.78	10.89	156.42	167.31	0	498	498	665.31
4	1.7	5.56	2.78	10.89	156.42	167.31	0	498	498	665.31
5	1.2	5.56	2.78	10.89	156.42	167.31	0	432	432	599.31
6	1.2	5.56	2.78	10.89	156.42	167.31	0	485	485	652.31
Farmers using knapsack sprayer										
7	1.2	6.67	0.00	13.07	0	13.07	0	501	501	514.07
8	1.2	6.67	0.00	13.07	0	13.07	0	485	485	498.07
9	0.6	6.67	0.00	13.07	0	13.07	0	485	485	498.07
10	1.2	6.67	0.00	13.07	0	13.07	0	477	477	490.07
11	1.4	6.67	0.00	13.07	0	13.07	0	498	498	511.07
12	1.4	6.67	0.00	13.07	0	13.07	0	432	432	445.07
13	2	6.67	0.00	13.07	0	13.07	0	491	491	504.07
14	1	6.67	0.00	13.07	0	13.07	0	480	480	493.07
15	1.2	6.67	0.00	13.07	0	13.07	0	485	485	498.07
16	0.6	6.67	0.00	13.07	0	13.07	0	491	491	504.07
17	1.6	6.67	0.00	13.07	0	13.07	0	501	501	514.07
18	1.6	6.67	0.00	13.07	0	13.07	0	477	477	490.07
19	1.6	6.67	0.00	13.07	0	13.07	0	491	491	504.07
20	1.2	6.67	0.00	13.07	0	13.07	0	480	480	493.07
21	1.2	6.67	0.00	13.07	0	13.07	0	485	485	498.07

22	1.6	6.67	0.00	13.07	0	13.07	0	491	491	504.07
23	1.6	6.67	0.00	13.07	0	13.07	0	501	501	514.07
24	2	6.67	0.00	13.07	0	13.07	0	485	485	498.07
25	1.2	6.67	0.00	13.07	0	13.07	0	485	485	498.07
26	1.3	6.67	0.00	13.07	0	13.07	0	477	477	490.07
27	1.4	6.67	0.00	13.07	0	13.07	0	432	432	445.07
28	2	6.67	0.00	13.07	0	13.07	0	491	491	504.07
29	1.4	6.67	0.00	13.07	0	13.07	0	480	480	493.07
30	1	6.67	0.00	13.07	0	13.07	0	485	485	498.07
31	0	6.67	0.00	13.07	0	13.07	0	491	491	504.07
32	0	6.67	0.00	13.07	0	13.07	0	501	501	514.07
33	0	6.67	0.00	13.07	0	13.07	0	485	485	498.07
34	2	6.67	0.00	13.07	0	13.07	0	477	477	490.07
35	2	6.67	0.00	13.07	0	13.07	0	498	498	511.07
36	1.2	6.67	0.00	13.07	0	13.07	0	432	432	445.07
37	1.8	6.67	0.00	13.07	0	13.07	0	491	491	504.07
38	1.6	6.67	0.00	13.07	0	13.07	0	480	480	493.07
39	1.6	6.67	0.00	13.07	0	13.07	0	485	485	498.07
40	1.6	6.67	0.00	13.07	0	13.07	0	491	491	504.07
41	1.6	6.67	0.00	13.07	0	13.07	0	501	501	514.07
42	1.5	6.67	0.00	13.07	0	13.07	0	485	485	498.07
Average		6.51	0.40	12.76	22.35	35.10	0.00	483.00	483.00	518.10

Table E 6.5 Consumption of Direct and Indirect Energy Sources in Plant Protection Operation by Marginal Farmers

Farmer Number	Area Under	Man-hr	Fuel Consumption	Direct Energy			Indirect Energy			Total
				Human Energy	Fuel Energy	Total	Machinery	Chemical	Total	
	ha	h/ha	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha
Farmers using knapsack sprayer										
1	0.4	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
2	0.8	6.67	0.00	13.07	0	13.07	0	477.00	477.00	490.07
3	0.8	6.67	0.00	13.07	0	13.07	0	498.00	498.00	511.07
4	0.2	6.67	0.00	13.07	0	13.07	0	432.00	432.00	445.07
5	0.8	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
6	1	6.67	0.00	13.07	0	13.07	0	480	480	493.07
7	0.4	6.67	0.00	13.07	0	13.07	0	485	485	498.07
8	0.4	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
9	0.4	6.67	0.00	13.07	0	13.07	0	501.00	501.00	514.07
10	0.8	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
11	0.6	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
12	0.2	6.67	0.00	13.07	0	13.07	0	477.00	477.00	490.07
13	0.4	6.67	0.00	13.07	0	13.07	0	498.00	498.00	511.07
14	0.8	6.67	0.00	13.07	0	13.07	0	432.00	432.00	445.07
15	0.3	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
16	0.8	6.67	0.00	13.07	0	13.07	0	480	480	493.07
17	0.6	6.67	0.00	13.07	0	13.07	0	485	485	498.07
18	0.4	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
19	0.8	6.67	0.00	13.07	0	13.07	0	501.00	501.00	514.07
20	1	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07

21	1	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
22	1	6.67	0.00	13.07	0	13.07	0	477.00	477.00	490.07
23	0.4	6.67	0.00	13.07	0	13.07	0	498.00	498.00	511.07
24	0.2	6.67	0.00	13.07	0	13.07	0	432.00	432.00	445.07
25	0.3	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
26	0.3	6.67	0.00	13.07	0	13.07	0	480	480	493.07
27	0.2	6.67	0.00	13.07	0	13.07	0	485	485	498.07
28	0.4	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
29	0.6	6.67	0.00	13.07	0	13.07	0	501.00	501.00	514.07
30	0.6	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
31	0.8	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
32	0.4	6.67	0.00	13.07	0	13.07	0	477.00	477.00	490.07
33	0.9	6.67	0.00	13.07	0	13.07	0	498.00	498.00	511.07
34	1	6.67	0.00	13.07	0	13.07	0	432.00	432.00	445.07
35	0.4	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
36	0.3	6.67	0.00	13.07	0	13.07	0	480	480	493.07
37	0.6	6.67	0.00	13.07	0	13.07	0	485	485	498.07
38	1	6.67	0.00	13.07	0	13.07	0	491.00	491.00	504.07
39	0.8	6.67	0.00	13.07	0	13.07	0	501.00	501.00	514.07
40	0.8	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
41	1	6.67	0.00	13.07	0	13.07	0	485.00	485.00	498.07
Average		6.67	0.00	13.07	0.00	13.07	0.00	482.56	482.56	495.63

Table E-7.1 Consumption of Direct and Indirect Energy Sources in Harvesting and Threshing Operation by Large Farmers

Farmer Number	Area under wheat	Man hour	Fuel Consumption	Direct Energy			Indirect Energy	Total Energy Consumption
				Fuel Energy	Human Energy	Total		
	ha	h	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha
1	12	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
2	24	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
3	40	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
4	10	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
5	20	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
6	17.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
7	14	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
8	11.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
9	10	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
10	72	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
11	12	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
12	11	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
13	20	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
14	16.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
15	32	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
16	18	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
17	16	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
18	30.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
19	20	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
20	11.6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
21	24.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
22	28	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
23	32	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
24	18.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
25	16	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
26	22	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
27	24	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
28	12	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
29	10	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
30	16	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
31	15.2	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
32	22.8	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
33	10	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
34	12	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
35	12	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
36	20	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
37	66	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
38	28	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
39	10	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
40	52.8	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
41	30.4	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
42	12.8	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
43	32	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
44	20	4.67	37.99	2139.29	9.16	2148.45	162.39	2310.84
45	16	300	41.59	2341.85	588	2929.85	203.28	3133.13
Average		11.24	36.10	2032.56	22.02	2054.58	163.30	2217.88

Table E-7.2 Consumption of Direct and Indirect Energy Sources in Harvesting and Threshing Operation by Medium Farmers

Farmer Number	Area under wheat	Man hour	Fuel Consumption	Direct Energy			Indirect Energy	Total Energy Consumption
	ha			h	l/ha	Fuel Energy		
Farmers harvesting the field by combine harvesters								
1	7.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
2	4.4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
3	4.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
4	7.27	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
5	5.6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
6	9.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
7	4.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
8	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
9	8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
10	4.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
11	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
12	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
13	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
14	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
15	4.6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
16	5.6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
17	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
18	4.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
19	7.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
20	8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
21	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
22	8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
23	4.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
24	8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
25	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
26	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
27	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
28	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
29	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
30	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
31	7.6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
32	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
33	6.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
34	8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
35	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
36	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
37	9.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
38	10	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
39	7.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
40	3	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
41	6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
42	7.6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
43	6.4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
44	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
45	4.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
Farmers harvesting the field manually								
46	8.08	300	32.35	1821.44	588	2409.44	144.52	2553.95
47	4.8	300	27.73	1561.23	588	2149.23	164.96	2314.19
48	4.8	300	46.21	2602.05	588	3190.05	188.1	3378.15
Average		23.13	34.85	1962.67	45.34	2008.01	162.61	2170.62

Table-E 7.3 Consumption of Direct and Indirect Energy Sources in Harvesting and Threshing Operation by Semi Medium Farmers

Farmer Number	Area under wheat ha	Man hour h	Fuel Consumption l/ha	Direct Energy			Indirect Energy MJ/ha	Total Energy Consumption MJ/ha
				Fuel Energy MJ/ha	Human Energy MJ/ha	Total MJ/ha		
Farmers harvesting the field by combine harvesters								
1	3.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
2	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
3	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
4	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
5	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
6	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
7	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
8	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
9	3.4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
10	3.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
11	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
12	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
13	3.23	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
14	2.02	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
15	2.4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
16	3.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
17	2.57	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
18	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
19	3.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
20	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
21	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
22	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
23	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
24	4.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
25	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
26	3.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
27	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
28	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
29	2.4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
30	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
31	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
32	2.4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
33	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
34	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
35	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
36	3.6	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
37	3.2	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
38	2.4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
39	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
40	3	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
41	4	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
42	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
43	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
44	2.8	4.67	34.82	1960.52	9.16	1969.68	162.39	2132.07
Farmers manually harvesting the crop								
45	4	300	36.04	2029.6	588	2617.6	250.34	2867.94
46	2.8	300	36.04	2029.6	588	2617.6	254.45	2871.07
47	2	300	36.04	2029.6	588	2617.6	188.1	2805.7
48	2.4	300	46.21	2602.05	588	3190.05	125.4	3315.45
49	2.8	300	46.21	2602.05	588	3190.05	188.1	3378.15
Average		40.11	34.12	1921.19	78.62	1999.81	166.79	2166.60

Table E 7.4 Consumption of Direct and Indirect Energy Sources in Harvesting and Threshing Operation by Small Farmers

Farmer Number	Area under wheat	Man hour	Fuel Consumption	Direct Energy			Indirect Energy	Total Energy Consumption
				Fuel Energy	Human Energy	Total		
	ha	h	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha
Farmers harvesting the field by combine harvesters								
1	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
2	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
3	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
4	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
5	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
6	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
7	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
8	1.21	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
9	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
10	1.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
11	1.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
12	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
13	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
14	1.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
15	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
16	1.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
17	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
18	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
19	1.8	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
20	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
21	1.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
22	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
23	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
24	1.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
25	1.8	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
26	1.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
27	2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
28	1.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
29	1.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
Farmers manually harvesting the field								
30	1.4	300	55.45	3122.46	588	3710.46	188.1	3898.56
31	1.21	300	36.04	2029.6	588	2617.6	150.48	2768.08
32	1.6	300	36.97	2081.64	588	2669.64	249.32	2918.96
33	2	300	32.35	1821.44	588	2409.44	168.61	2578.04
34	1.2	300	36.04	2029.6	588	2617.6	166.9	2784.5
35	1.6	300	36.97	2081.64	588	2669.64	125.4	2795.04
36	1.3	300	36.97	2081.64	588	2669.64	125.4	2795.04
37	1.2	300	23.1	1301.03	588	1889.03	188.1	2077.13
38	1.6	300	44.36	2497.97	588	3085.97	169.4	3255.37
39	1.7	300	32.35	1821.44	588	2409.44	252.91	2662.34
40	1.2	300	36.04	2029.6	588	2617.6	125.4	2743
41	1.61	300	36.04	2029.6	588	2617.6	150.48	2768.08
42	1.6	300	48.06	2706.13	588	3294.13	267.44	3561.58
Average		96.58	38.56	2171.43	189.30	2360.72	184.80	2545.53

Table D 7.5 Consumption of Direct and Indirect Energy Sources in Harvesting and Threshing Operation by Marginal Farmers

Farmer Number	Area under wheat	Man hour	Fuel Consumption	Direct Energy			Indirect Energy	Total Energy Consumption
				Fuel Energy	Human Energy	Total		
	ha	h	l/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha	MJ/ha
Farmers harvesting the field by combine harvesters								
1	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
2	0.8	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
3	0.8	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
4	0.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
5	1	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
6	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
7	0.5	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
8	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
9	0.81	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
10	0.2	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
11	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
12	0.81	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
13	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
14	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
15	0.8	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
16	1	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
17	1	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
18	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
19	1	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
20	1	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
21	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
22	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
23	0.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
24	0.8	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
25	0.8	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
26	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
27	0.9	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
28	1	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
29	0.4	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
30	0.27	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
31	0.6	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
32	1	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
33	0.8	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
34	1	5.39	40.17	2262.14	10.57	2272.71	187.37	2460.08
Farmers harvesting the field manually								
35	1.6	300	48.06	2706.13	588	3294.13	267.44	3561.58
36	0.61	300	36.97	2081.64	588	2669.64	125.4	2795.04
37	0.8	300	41.59	2341.85	588	2929.85	188.1	3117.95
38	0.8	300	36.97	2081.64	588	2669.64	188.1	2857.74
39	1	300	36.97	2081.64	588	2669.64	125.4	2795.04
40	0.8	300	32.35	1821.44	588	2409.44	169.63	2579.07
41	0.8	300	36.92	2079.14	588	2667.14	125.4	2792.54
42	0.6	300	23.1	1301.03	588	1889.03	165.3	2054.33
Average		55.69	39.29	2212.22	109.16	2321.38	181.90	2503.28

VITAE

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ABSTRACT

Energy is the key input for crop production. Crop yield is affected by the use of energy sources and their magnitude like human power, machines, irrigation, fertilizers, pesticides, diesel etc. In crop production system, increased production requires efficient use of energy resources. Wheat is the most important cereal crop in northern India as well as in Tarai region of Uttarakhand. Effective planning of agriculture and to meet future energy demand, it is necessary to analyze current scenario of energy consumption in crop production system. Therefore, an attempt was made to analyze energy consumption pattern in wheat crop production in Tarai region of Uttarakhand.

The average farm power availability in Tarai region of Uttarakhand was found 2.05 kW/ha. The average farm power availability of large, medium, semi medium, small and marginal farmers was found 3.13, 4.11, 2.7, 2.1 and 1.65 kW/ha respectively. Tarai region of Uttarakhand is highly mechanized, and mechanization index for harrowing operation in wheat crop production for large, medium, semi medium, small and marginal farmers was found 97%, 97%, 97%, 96% and 96 % respectively. The mechanization index for planking operation for large, medium, semi medium, small and marginal farmers was found 96%, 94%, 94%, 93% and 92 % respectively. In sowing operation mechanization index for large, medium, semi medium, small and marginal farmers were found 96%, 73%, 65%, 63% and 16 % respectively. Mechanization index for irrigation operation in wheat crop production for large, medium, semi medium, small and marginal farmers was observed as 71%, 62%, 49%, 52% and 57 % respectively. The average mechanization index for plant protection operation in wheat crop production for large, medium, semi medium, small and marginal farmers was observed 56%, 31%, 6%, 10% and 0 % respectively. The mechanization index for harvesting and the threshing operation was found 90%, 90%, 88%, 87% and 89% for large, medium, semi medium, small and marginal categories, respectively. Total energy consumption in wheat cultivation was observed as 24882.5, 23322.0, 21361.1, 20206.8 and 20030.1 MJ/ha for large, medium, semi medium, small and marginal category of farmer respectively. The average energy consumption in wheat production in the Tarai region of Uttarakhand is 20497 MJ/ha with the corresponding yield of 4.2 t/ha. The energy ratio for the large, medium, semi-medium, small and marginal category has been found as 3.26, 3.15, 3.14, 3.11 and 2.95, respectively. The average fuel and electricity use for wheat crop production was found to be 82.1 l/ha and 171.8 kWh/ha respectively.


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मुख्या विषय	: कृषि प्रक्षेत्र शक्ति एवं यांत्रिकी अभियंत्रण	विभाग	: कृषि प्रक्षेत्र शक्ति एवं यांत्रिकी अभियंत्रण
शोध ग्रन्थ विषय	: उत्तराखंड के तराई क्षेत्र में गेहूँ की फ़सल में उर्जा की खपत का अध्ययन		
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सारांश

उर्जा फ़सल उत्पादन का प्रमुख इनपुट है। किसी फ़सल का उत्पादन, उर्जा की खपत और उसके परिमाण जैसे मानवीय उर्जा, मशीनी उर्जा, सिंचाई, उर्वरक और पेस्टिसाइड आदि पर निर्भर करता है। फ़सल के उत्पादन को बढ़ाने के लिए उर्जा स्रोतों का कुशल उपयोग अत्यंत आवश्यक है। गेहूँ उत्तर भारत के साथ साथ उत्तराखंड के तराई क्षेत्र की भी एक महत्वपूर्ण फ़सल है। कृषि की योजनात्मक नियोजन के लिए यह अत्यंत आवश्यक है की फ़सल उत्पादन में उर्जा की खपत का विश्लेषण किया जाये। इसलिए गेहूँ की फ़सल में उर्जा की खपत के अध्ययन का एक प्रयास किया गया।

उत्तराखंड के तराई क्षेत्र में फार्म पॉवर की औसत उपलब्धता 2.01 कि वा/है पाई गयी जिसमें बड़े, मध्यम, अल्प मध्यम, छोटे और सीमान्त किसानों के पास फार्म पॉवर की उपलब्धता क्रमशः 3.13, 4.11, 2.7, 2.1 और 1.65 कि॰वा॰/है॰ पाई गयी। तराई क्षेत्र में, कृषि में मशीनीकरण का स्तर काफी ऊँचा है। जुताई प्रक्रिया में मशीनीकरण अंक बड़े, मध्यम, अल्प मध्यम, छोटे और सीमान्त किसानों के लिए क्रमशः 97%, 97%, 97%, 96% एवं 96 % पाया गया। इसी प्रकार पटेला प्रक्रिया में मशीनीकरण अंक बड़े, मध्यम, अल्प मध्यम, छोटे और सीमान्त किसानों के लिए क्रमशः 96%, 94%, 94%, 93% एवं 92 % पाया गया। बुवाई प्रक्रिया में मशीनीकरण अंक बड़े, मध्यम, अल्प मध्यम, छोटे और सीमान्त किसानों के लिए क्रमशः 96%, 73%, 65%, 63% एवं 16 % पाया गया। सिंचाई में मशीनीकरण अंक क्रमशः 71%, 62%, 49%, 52% एवं 57 % पाया गया। फ़सल सुरक्षा में मशीनीकरण अंक का स्तर क्रमशः 56%, 31%, 6%, 10% एवं 0% पाया गया। फ़सल की कटाई और मढ़ाई प्रक्रिया में मशीनीकरण अंक का स्तर क्रमशः 90%, 90%, 88%, 87% एवं 89% पाया गया। गेहूँ की फ़सल में बड़े, मध्यम, अल्प मध्यम, छोटे और सीमान्त किसानों के लिए कुल उर्जा की खपत क्रमशः 24882.5, 23322.0, 21361.1, 20206.8 एवं 20030.1 MJ/ha पाई गयी। तराई क्षेत्र में गेहूँ की फ़सल में औसत उर्जा की कुल खपत 20497 MJ/ha पाई गयी जिसके साथ 4.2 t/ha की पैदावार मिली। बड़े, मध्यम, अल्प मध्यम, छोटे और सीमान्त किसानों के लिए के लिए उर्जा का अनुपात क्रमशः 3.26, 3.15, 3.14, 3.11 और 2.95 पाया गया। तराई क्षेत्र में गेहूँ फ़सल उत्पादन में कुल डीजल और बिजली की खपत 82.1 लि/है और 171.8 यूनिट/है पाई गयी।


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